Reduce Water Temperatures in the Teanaway Project Final Project Report

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Abstract

The Teanaway River is one of the major tributaries of the upper Yakima River, and it drains the upper reaches of the Yakima River on the east slope of the Cascade mountain range. The basin currently experiences high stream temperatures detrimental to threatened salmonids (steelhead and bull trout) as well as to spring chinook and resident trout. There are eight waterbodies in the Teanaway Basin identified on Washington State's latest 303(d) list as being impaired for temperature. Ecology verified these listings in 1998, when data collected for the Temperature TMDL showed that the middle and lower basin exceeded the 18°C water quality standard in over 75% of the days monitored.

Elevated sediment and turbidity levels were also documented in studies by Ecology and the Kittitas County Conservation District. More comprehensive monitoring and study of the temperature and sediment levels was identified as a need by the Kittitas County Conservation District and TMDL Work Group. This project collected sediment, turbidity and discharge at eleven sites and temperature data at ten sites in the Teanaway basin from the edge of Forest Service lands on the North Fork to the mouth of the Teanaway.

Three main remedies to reducing water temperatures were recommended in Ecology's 2000 technical report on water temperatures in the Teanaway Basin: 1) restore riparian vegetation to increase shade and stabilize banks, 2) increase in-stream flows, and 3) reduce sediment inputs to the Teanaway by improving road conditions and stabilizing banks. This offsite mitigation project pursued two of these goals. Efforts to restore riparian vegetation involved planting two thousand trees at two sites along the banks of the Teanaway River. Irrigation systems were upgraded, and points of diversion moved, increasing in-stream flows by as much as three cubic feet per second.

Introduction

The Teanaway Basin is located in northwest Kittitas County, east of the Cascade Crest, and the basin lies approximately 5 miles north of the town of Cle Elum, Washington. The Teanaway River flows primarily to the southeast, and joins with the upper Yakima River about 3 miles southeast of Cle Elum. It is a large tributary, with a drainage area of over 200 square miles. The Teanaway River has three main forks: the North, West and Middle Forks. Both forestry (logging) and agriculture have had significant impacts on the land historically; today the main land uses are forestry, cattle grazing, irrigated agriculture and recreation.

The Teanaway Basin currently experiences high stream temperatures detrimental to threatened salmonids (steelhead and bull trout) as well as to spring chinook and resident trout. There are eight waterbodies in this basin that have been identified on Washington State's latest list of impaired waterbodies (the 1998 303(d) list) as being impaired for temperature (Ecology, 1998). Ecology verified these listings in 1998, when data showed that the middle and lower basin exceeded the 18°C water quality standard in over 75% of the days monitored (Stohr, 2000). Additionally, the lower portion of the Teanaway mainstem has been identified as impaired for in-stream flows (Ecology, 1998).

The Teanaway was historically one of the top producers of spring chinook, steelhead, and coho in the entire Yakima watershed (Berg, 2001). With remediation of a number of significant habitat problems, the physical diversity and size of the Teanaway guarantee it could still be a major producer. A recent EDT simulation of Yakima Basin spring chinook

indicated that that the Teanaway River was one of the top five portions of the entire basin in terms of restoration potential, and that if it were fully restored to historical conditions, productivity and equilibrium abundance would be doubled basin-wide. Suitable spawning gravels and gradients for all three species are present in most reaches of the mainstem and the lower portions of the forks, and are abundant in many areas. The upper reaches of the forks of the Teanaway, as well as the lower reaches of a fair number of small, North Fork tributaries could provide additional spawning habitat for steelhead and possibly coho (Berg, 2001).

Using continuous water temperature data gathered from July 1 to October 8, 1998, the Teanaway River Basin Temperature Pilot Technical Assessment found that the middle and lower basin exceeded the 18°C water quality standard in over 75% of the days monitored (Stohr, 2000). This study also found that analysis and stream temperature modeling with Stream Segment Temperature Model (SSTEMP) indicated that improvements in riparian shade, active channel width, and flow can lower these temperatures (active channel width can be reduced if sediment load is reduced). Estimates made with the best available data are that a 1.5°C to 3°C reduction in mean daily water temperature could be realized with a mature riparian buffer, sediment controls for roads, and stream flow increases. The reduction in maximum daily water temperature would be approximately 3°C to 6°C under the most favorable simulated conditions (Stohr, 2000). These estimates are made for a critical condition, which for stream temperature is a time of low flow and high air temperature.

The Kittitas County Conservation District (KCCD) also sampled the lower Teanaway River between 1994 and 1996. They found that water temperatures reached 22° C during the summer and 21° C in the fall. Turbidity and suspended solids were elevated during late winter and spring run-off events. Teanaway sediment loadings were found to be higher than any other upper Yakima River tributary (TriCounty et al., 2001).

Stream temperature is increased by lack of riparian shade, excessive sediment load, and low stream flow. Land management activities, such as forest management, grazing, and agriculture, may affect temperature adversely where they damage vegetation adjacent to streams, cause excessive erosion of stream banks, add sediment to streams, reduce instream flow, or return warmed waters to the stream.

The mainstem reach of the Teanaway River drainage has often been seasonally dewatered, and the three upgradient reaches experience serious soil erosion mainly due to timber harvest and forest roads (TriCounty et al., 2001). Low flows in this basin also cause stream flow to be lost to bedload, and channel migration occurs at an accelerated rate. This, in conjunction with unstable streambanks, results in increased sediment recruitment that further exacerbates the limited flow (USFS, 1998). Furthermore, stream channel entrenchment (downcutting) is widespread in the Teanaway River watershed, leading to accelerated stream bank erosion and accumulations of fine sediments in stream gravels (TriCounty et al., 2001).

Methods and materials

This project involved five objectives and multiple tasks. Initially these tasks were divided between two sub contractors, the KCCD and the Natural Resources Conservation Service (NRCS). In early 2003, due to staffing issues, the KCCD assumed the responsibility for the tasks assigned to the NRCS. The following tasks and objectives are guoted directly from the scope of work as amended in December 2003.

Objective 1: Increase irrigation efficiency on agricultural lands in lower Teanaway Basin.

Task 1.1 Move points of diversion. Methods: The properties involved receive irrigation water from an unlined ditch about 2.5 miles long. The new water intake will be much closer to the irrigated lands, over two miles downstream from the previous diversion point. As part of the new system, the water will be pumped from a ring well or a screened pump intake in the river, and will be moved through a pressurized line to the newly installed sprinkler system. If a pump intake is used, some minor instream work may be necessary to ensure effective placement of the intake. Best management practices for irrigation improvement (most notably NRCS Field Office Technical Guides (FOTGs) and NMFS guidance on screening) will be followed when designing and installing the pump and piping system.

Task 1.2. Upgrade irrigation equipment from rill to sprinkler. Methods: The landowners will be encouraged to upgrade their on-farm irrigation water application systems as feasible. Some landowners may convert their rill irrigation systems to center pivot sprinkler systems. Sprinklers are a standard irrigation best management practice, and are preferable to rill irrigation as they 1) use less water to meet plant growth needs and 2) produce little or no runoff water that can pollute receiving waters. Standard best management practices for irrigation improvement (e.g., NRCS FOTGs) will be followed when designing and installing the sprinkler systems.

Objective 2: Restore riparian vegetation in Teanaway Basin: Revegetating riparian areas has been shown to be an effective method of restoring riparian zones and, ultimately, reducing stream temperatures.

> Task 2.1. Plant native trees in riparian areas. Methods: An experienced tree planting crew, such as the Washington Conservation Corps, will plant native trees by hand along exposed sections of the banks of the Teanaway River and its tributaries.

Objective 3: Monitor effectiveness of actions performed for this project

Task 3.1: Monitor effectiveness of irrigation improvements. Methods: Model water saving and sediment reduction using standard NRCS procedures and formulas. Conduct ongoing data collection of in-stream flows. Continue to monitor and report data if additional funds become available.

Task 3.2: Monitor effectiveness of tree planting. Methods: Assess survival rates following planting – this will entail visiting the sites where tree planting occurred, and making estimates of the percentage of trees that survived over time.

Objective 4: Conduct monitoring to further assess water quality (temperature and sediment) in the Teanaway Basin Methods: A quality assurance project plan (QAPP) will be developed to determine sample site location and to direct sample collection techniques. Eight to ten temperature monitoring sites, and eight to ten sediment monitoring sites will be selected throughout the Teanaway Basin. The sampling sites will be chosen by a) their importance to identifying either temperature

increases or sediment sources, b) their contribution of background data, as well as c) their accessibility. Sediment samples will be collected at least every two weeks during the critical period of high sediment load (at least February through June), with additional samples collected during significant high flow events outside the critical period (at least November through April). These high flow events can include rapid snowmelt or rain-on-snow events. Temperature samples will be collected (at a minimum) during the warmest time of the year, at least June through September. The data collection phase of this study will encompass the following:

- collect temperature data, via 1) continuous loggers and 2) spot checks while staff are in field (to verify loggers)
- collect water column samples, and have these samples analyzed for sediment and turbidity
- measure in-stream flows at several points in the Teanaway R. and its tributaries

Objective 5: Reporting, project management and data input. The progress reports will be relatively brief project management administrative reports. annual report will be comprehensive, and will include (at a minimum) a summary of data collected, and a clear, detailed description of all tasks completed during the year. All data collected will be input into an approved data system (exact system not yet determined by BPA) by the KCCD with assistance from Ecology, to ensure public access to the data.

> Task 5.2: Quarterly and annual reporting and project coordination. As noted previously, Ecology will complete the annual reports and quarterly progress reports, as well as oversee general project administration. All of Ecology's time will be contributed (not reimbursed by BPA).

Results and Discussion

The priority locations for each of the objectives were determined using a variety of data. One such dataset was the forward looking infrared (FLIR) data collected by the US

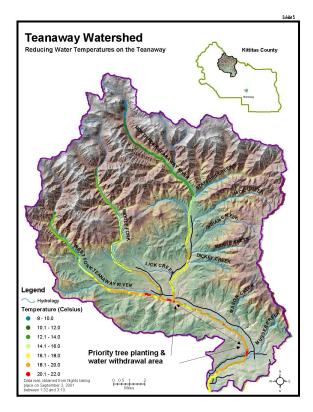


Figure 1: Priority work areas in the Teanaway Basin overlaid on the FLIR data collected by the USFS.

Forest Service. The data is collected with equipment mounted in a helicopter. The helicopter then flies over the water In the case of the Teanaway River, data was collected from the mouth at the Yakima River up to the headwaters of each of the three forks. See Figure 1. The resulting data was helpful in confirming the areas of potential concern. In addition, the water quality monitoring effort (specifically the temperature monitoring) was coordinated with the work of the US Forest Service and built on the data collected by the Department of Ecology during their TMDL monitoring. The irrigation upgrades and riparian efforts revegetation also build previous and ongoing work in the Teanaway Basin.

The following results specifically relate to Objectives 1, 2 and 4. Supporting information may be found in the Appendices.

Objective 1: Increase Irrigation Efficiency on Agricultural Lands

While discussions and concept drawings began before the grant agreement was signed, the formal effort to design new irrigation systems did not begin until May 2003. The NRCS held the original subcontract to design the irrigation systems. Due to staffing changes, the KCCD agreed to assume NRCS's responsibility in early 2003.

The Ballard Ditch is a small irrigation delivery canal in the Teanaway Valley; a gravel push-up dam has historically been used to divert water from the mainstem Teanaway River into the Ballard Ditch. A total; of five landowners utilized the ditch to irrigate over 200 acres of cropland and provide stockwater. Landowners who drew water from the Ballard Ditch were contacted about the available assistance and the possibility of changing their points of diversion and upgrading the irrigation systems. Their collective water right is just over 4 cubic feet per second. Four of the five landowners agreed to participate. The fifth landowner, with a small stockwater right, chose not to accept technical or financial assistance.

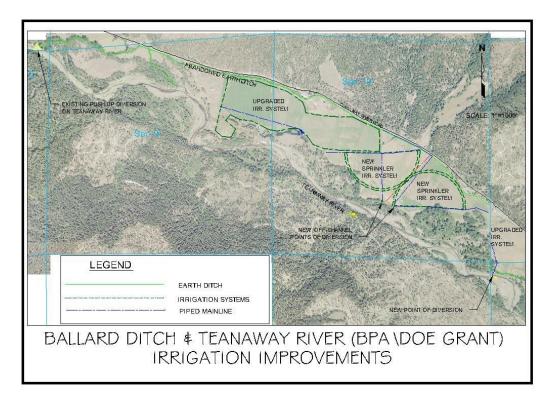


Figure 2: Irrigation Efficiency projects along the Teanaway

Each landowner has, or will have their own water source located on or very near their property. Two of the landowners will be able to utilize shallow ring wells in continuity with the river. Another will use an existing pond. The fourth may withdraw via a pump directly from the river at a point 2.5 miles downstream from the existing Ballard Ditch diversion point.

In addition to the change in location of their diversions, the landowners also upgraded their on-farm systems. Above ground mainlines serving existing sprinkler systems have been replaced by buried PVC piping. Rill irrigation systems (gated pipe) will be replaced on nearly half the acreage by center pivot sprinkler systems.

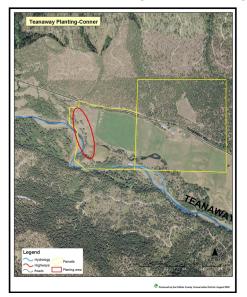
Approximately \$60,000 in cost share funds were paid to the landowners to assist with the upgrades. Two of the four landowners also secured additional funding through the Natural Resources Conservation Service's Environmental Quality Incentives Program (EQIP) and/or the KCCD's Irrigation Efficiencies Program.

Over three cubic feet per second of water will remain in-stream as a result of these projects. During low flows, like those seen in 2003, that volume of water could be as much as 25 percent of the flow of the mainstem of the Teanaway River.

The Bonneville Power Administration has worked in the Teanaway in the past, establishing three pumping sites to replace other gravity flow diversions. The pumping sites are located at and between Red Bridge Road and Lambert Road. The majority of the irrigators in the Teanaway Watershed are now served by pressurized systems.

Objective 2: Restore Riparian Vegetation in Teanaway Basin

Two locations along the mainstem of the Teanaway River were secured for the restoration of riparian vegetation. See Figure 3 and Figure 3 below.



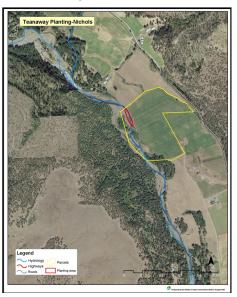


Figure 3 and Figure 4: Tree planting sites along the mainstem of the Teanaway River.





Figure 5 and Figure 6: Benchmark photos of the plantings at Conner property (left) and Nichols property (right) along the mainstem Teanaway River.

The tree planting was completed on October 31, 2003. Two thousand containerized and bareroot stock were planted by a 7-person Americorp team at two sites. Most of the stock was in great shape and tree protectors and weed mats were used for most of the planting. The weather was a slight issue as it was very cold during three days of the planting effort.

Several hundred of the trees were planted at a one acre site owned by Olin Nichols. The property adjacent to the Teanaway River is eroding significantly and much of the area has little or no riparian vegetation. The site was planted in 2001 using Department of Ecology Funds in an effort coordinated by David Chain, Natural Resources Conservation Service District Conservationist. That effort failed because of the 2001 drought and poor coordination with the landowner. The landowner at this site also worked with the Mid Columbia Regional Fisheries Enhancement Group (MCRFEG) to install rock barbs in the eroding bank. When the KCCD contacted Mr. Nichols in 2003, he was eager to pursue another planting effort. Mr. Nichols agreed to ensure the trees and shrubs receive irrigation in subsequent seasons. He is able to irrigate with his existing wheel line sprinkler system.

The remaining trees were planted at the second site owned by John Conner. The area in need of riparian vegetation is in an area that was protected by a dike. In the high flow events of the late 1990's, the dike was breached. The area retained only a few large trees. The newly planted trees will help reinforce the degraded banks and, in time, produce needed shade. These trees will be supplemented by irrigation water where possible, and drip lines in hard to access areas.

Objective 4: Conduct Monitoring to further assess water quality (temperature and sediment) in the Teanaway Basin

Discharge

Comprehensive measurements of discharge in the Teanaway basin were collected from November 2002 through December 2003. The measurements occurred at the eleven sampling sites (see Figure 7). Flows were correlated to the Bureau of Reclamation gaging station below the confluence of the forks on the mainstem Teanaway River. A continuous gaging station allows the KCCD sampling events to be understood in overall context of the flow levels in the Teanaway River (see Figure 10).

Photographs of the two mainstem sites (at Lambert and Red Bridge Road) provide a visual representation of the variation in flows over the course of a season. See Figure 8 and Figure 9.

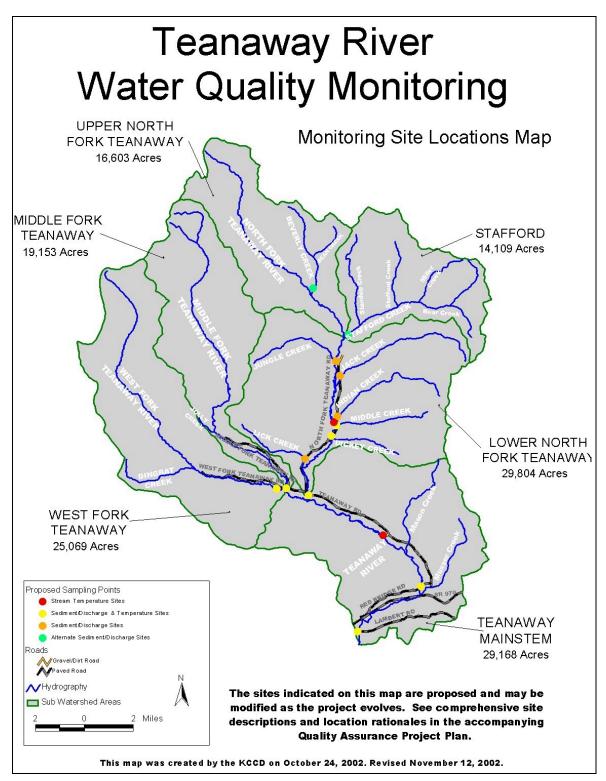


Figure 7: Water quality monitoring locations.



Figure 8: The mainstem Teanaway River at the Lambert Road bridge on the following dates (clockwise from upper left) December 30, 2002, March 14, 2003, August 26, 2003, and October 22, 2003.



Figure 9: The mainstem Teanaway River at the Red Bridge Road bridge on the following dates (clockwise from upper left) December 30, 2002, March 14, 2003, August 26, 2003, and October 22, 2003.

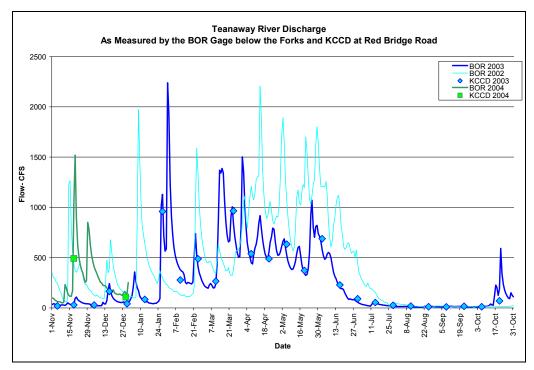


Figure 10 KCCD sample events superimposed on the continuous flow data collected by the USBR Gaging Station.

The USBR continuous gaging station is on the mainstem of the Teanaway. It is important in the study of the suspended sediment and turbidity to understand how flows are contributed from each of the forks. Table 1 displays the percentage of flow attributed to each fork for each sampling event. The majority of the flows are contributed by the North Fork, with an average of just over 60%, however when the flows are very low, the North Fork is responsible for as much as 89% of the flow.

The data in Figure 10 and Table 1 indicates that the Teanaway system is "flashy", that is it experiences very high highs and very low lows. The North Fork definitely maintains the greatest base flow of the forks. The West Fork and Middle Fork contained less than 2 CFS each in the driest part of the summer. See Figure 11. Data collection in future seasons will be essential in further defining the flow regimes of each fork.

The flashy flows may be a natural condition exacerbated by restricting access to floodplains; past and current grazing activities; and/or past and current logging practices. Logging practices remove the vegetation that made it possible for the upslope areas within the watershed to retain the precipitation, whether it is snow pack or rainfall instead allowing rapid movement into the Teanaway River and its tributaries. Grazing practices may also remove vegetation, although not to the same extent as the logging practices. Restricting access to the floodplain, concentrates large flows causing damage to streambanks and offering no mechanism to dissipate the energy of a flood flow or utilize the floodplain areas as a "reservoir" to hold water in the ground and release it back into the river during lower flows. The Teanaway is restricted from floodplain areas by dikes and roads (state highways, county roads, and private roads). No definitive data exists in the Teanaway watershed to verify the specific cause or causes of the flashy flows.

	Total Flow (Cubic Feet Per Second)	Middle Fork Percentage of Total Flow	West Fork Percentage of Total Flow	North Fork Percentage of Total Flow
5-Nov-02	18.2	15%	11%	75%
18-Nov-02	25.0	20%	16%	65%
4-Dec-02	26.5	21%	17%	62%
16-Dec-02	149.5	26%	27%	47%
30-Dec-02	44.5	26%	18%	56%
13-Jan-03	76.6	24%	19%	57%
27-Jan-03	1129.2	20%	24%	56%
10-Feb-03	280.5	23%	21%	56%
24-Feb-03	407.8	17%	28%	55%
10-Mar-03	217.3	18%	26%	56%
7-Apr-03	465.2	19%	19%	62%
21-Apr-03	560.7	27%	20%	53%
5-May-03	530.1	28%	18%	54%
19-May-03	387.0	26%	15%	59%
3-Jun-03	517.0	38%	17%	45%
16-Jun-03	236.7	22%	10%	69%
30-Jun-03	113.9	16%	8%	75%
14-Jul-03	57.4	13%	9%	78%
28-Jul-03	38.4	7%	7%	86%
11-Aug-03	23.3	11%	9%	80%
25-Aug-03	16.8	10%	2%	89%
8-Sep-03	11.4	6%	8%	86%
22-Sep-03	14.1	11%	11%	78%
6-Oct-03	12.7	6%	11%	83%
20-Oct-03	76.9	29%	11%	60%
3-Nov-03	47.8	25%	19%	56%
18-Nov-03	583	18%	31%	53%
29-Dec-03	116.3	22%	18%	61%
	Average	19%	16%	65%
	Median	20%	17%	61%
	Maximum	38%	28%	89%
	Minimum	5%	2%	45%

Table 1: Flow percentages for each of the forks of the Teanaway River.



Figure 11: (L to R) North Fork, Middle Fork and West Fork on August 26th. Eighty nine percent of the flow into the mainstem was contributed by the North Fork.

Suspended Sediment and Turbidity

Approximately 270 water samples were collected from 11 sites in the Teanaway system from November 2002 through December 2003. The sediment levels were generally extremely low, with a median turbidity value for all samples at all sites of less than 1 NTU. The maximum value was 119 NTU, found in Lick Creek during the high flow event in November 2003. With the exception of the high flow events, the samples collected at most of the sites generally met the Upper Yakima River Suspended Sediment TMDL goals for 2006. Lick Creek definitely has the greatest turbidity and the most exceedences of the 2006 goal of 18.6. See Figure 12 and Figure 13.

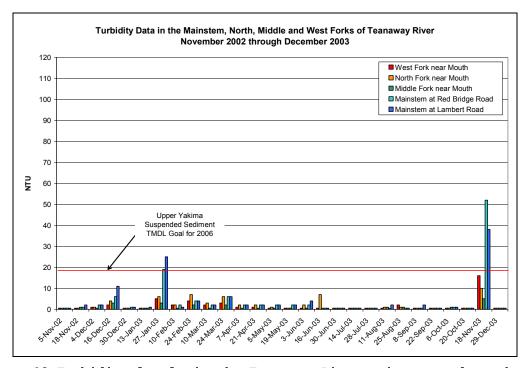


Figure 12 Turbidity levels in the Teanaway River mainstem and at the mouth of each of the three forks.

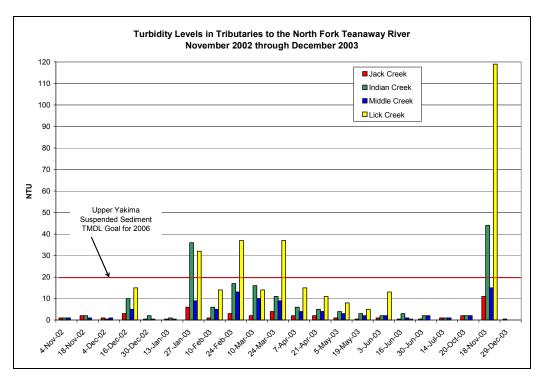


Figure 13. Turbidity levels in the North Fork Teanaway and several of it's tributaries.

Combining the discharge data and the suspended sediment data produces sediment loads from each of the sites. Of the three forks, the North Fork consistently produced the greatest sediment loads, corresponding with the consistently highest discharge. See Figure 14.

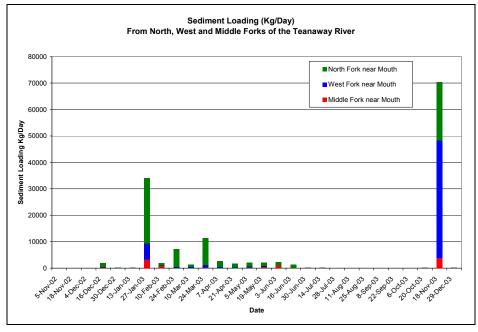


Figure 14 Sediment loading (kg/day) in each of the Teanaway River forks. The sediment loading calculations for the North Fork Teanaway and its tributaries show that Lick Creek, although being an intermittent stream, is capable of producing a

significant sediment load. See Figure 15. During much of the year, the sediment load is carried in the North Fork itself, although during higher flow events (e.g. snowmelt, rainstorm) the small tributaries can account for 80% to 90% of the sediment load. See Figure 16.



Figure 15: Lick Creek carried a significant sediment load, especially during storm events (left). Sediment depositions are obvious when the water is clearer.

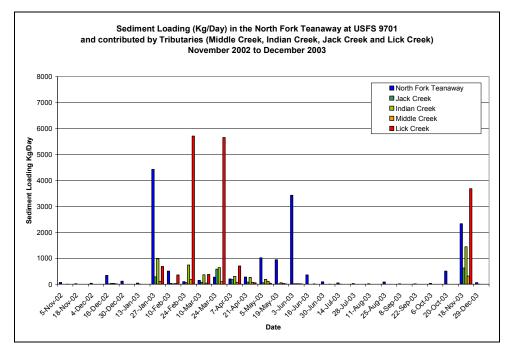


Figure 16. Sediment loading in the North Fork and it's tributaries.

Temperature

Temperature data was collected at five sites on the mainstem of the Teanaway, one each of the forks (just above their confluence), at two additional sites on the North Fork (near the North Fork confluences with Dickey Creek and Middle Creek) and in Jack Creek. The lowest site monitored was the mainstem Teanaway at Hwy 10, which is just upstream of the Teanaway's confluence with the Yakima River. The highest site monitored was Jack Creek, a tributary to the North Fork.

Water temperatures on the mainstem varied in a pattern very similar to the data collected during the FLIR flight in September 2001 (see Figure 1). The mainstem sites at Lambert Road, Red Bridge Road and Highway 970 generally displayed the highest temperatures. The sites near the mouth of each fork are similar. The sites up the North Fork displayed decreasing temperatures.

See Figure 17 for a display of the temperatures collected at all sites during eleven days of August of 2003. The only site that meets the 18°C standard is Jack Creek. It should be noted that the mainstem sites recorded the highest daily temperatures, but the lowest site at Hwy 10 recorded temperatures 3°C to 4°C lower than the Red Bridge Road and Lambert Road sites. It is likely that the large wetland area surrounding the reach of the Teanaway near this site supplies the river with cooler water through surface and groundwater flows.

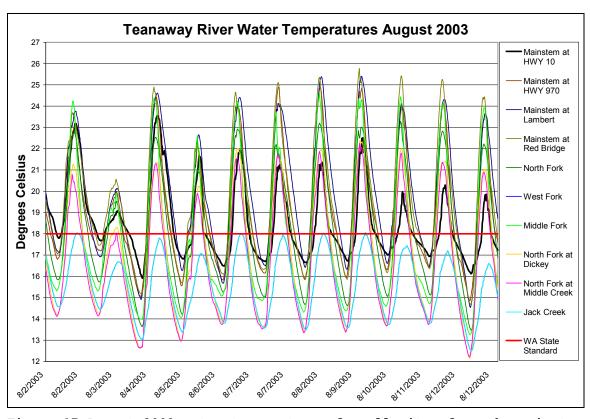


Figure 17 August 2003 water temperatures for all sites from the mainstem Teanaway at Highway 10 all the way up the North Fork to Jack Creek.

The North Fork Teanaway was monitored at three sites, one near the mouth, one near Dickey Creek and one near Middle Creek. A consistent increase in temperature was recorded between the site near the mouth of the North Fork and the site near Middle Creek. See Figure 18. That increase averaged 1.2°C during the 2003 season and 1.35°C in the 2002 season. The greatest temperature differential was 3.3°C in 2002 and 3.6°C in 2003. Those differences were recorded in late July and early August.

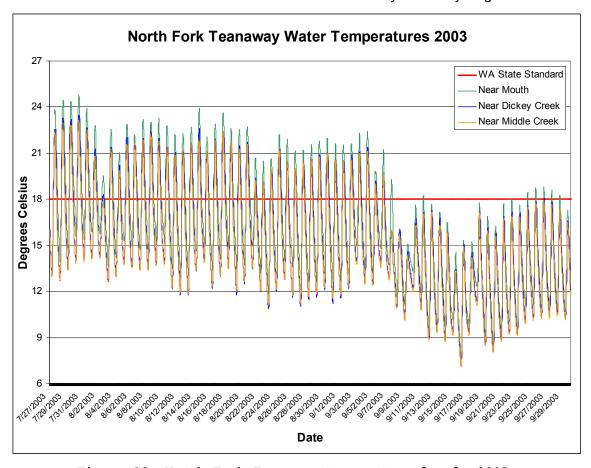


Figure 18 North Fork Teanaway temperature levels 2003.

Summary and conclusions

Objective 1: Increase Irrigation Efficiency on Agricultural Lands

This project successfully funded the improvement of irrigation systems and a decrease in water withdrawn by gravity diversion in the Teanaway River. The project resulted in 3.5 cfs remaining in the mainstem of the Teanaway River. In a very dry year, like 2003, that may be as much as 30% of the entire flow in the river. The project was able to match funds from other sources in order to achieve additional on-farm improvements. A similar effort should be offered to the water right holders on any remaining gravity diversions from the Teanaway River.

Objective 2: Restore Riparian Vegetation in Teanaway Basin

Success cannot be measured at this juncture; however every effort was expended to ensure maximum survivability of the 2,000 trees and shrubs. Additional sites should be located, especially along the mainstem of the Teanaway River, to revegetate the riparian and floodplain areas. Expected benefits of the trees and shrubs planted are bank stabilization and stream shading.

Objective 3: Monitor effectiveness of actions performed for this project

Due to the timing of project implementation, the effectiveness of the actions cannot be monitored using project funds. However, the KCCD has a grant agreement with Ecology to expand the tasks and goals of this project. That project is the Teanaway Restoration Project and it is funded by a centennial clean water grant through 2006. The Teanaway Restoration Project will allow the KCCD to continue to monitor the survival and growth of the trees and shrubs planted and the success of the actions to increase irrigation efficiencies.

Objective 4: Conduct Monitoring to further assess water quality (temperature and sediment) in the Teanaway Basin

The water quality and quantity data collected in the Teanaway River system is of great value for its comprehensive nature. Previous data collection focused only on the lowest portions of the mainstem. The data resulting from this study portray characteristics of the system into each of the three forks and even small tributaries of the North Fork. Additional water quality and quantity data should be collected in the Teanaway River system. Continuing the comprehensive collection of data, through the Teanaway Restoration Project will assist further activities to work toward the goals of the Teanaway Temperature TMDL and the Upper Yakima River Suspended Sediment TMDL.

It is clear from the data that during storm events, there is a significant increase in the sediment levels from each of the forks to the lowest site on the mainstem. Activities to decrease erosion in this reach are necessary.

Lick Creek is a significant source of sediment in the North Fork Teanaway. Anecdotal evidence from staff at the Washington Department of Ecology indicates that the erosion occurring in and along Lick Creek may be a natural

process and not one necessarily caused by human impacts¹. Further exploration of the options to address the sediment load is needed.

Temperature exceedences clearly occur in this system. Further data collection is necessary to document the conditions and to help in determining locations and types of actions to lower water temperatures. The KCCD has funds, through the Teanaway Restoration Project to collect data for at least two more seasons (2004 and 2005).

Summary of expenditures, including a list of major property purchased during the fiscal year

This project expended a total of \$183,700 over 22 months starting in June of 2002. Table 2 details those expenditures by budget category. These values represent the best estimate for many of the categories. To verify final costs, the vouchers submitted should be reviewed.

Budget Category	Direct Costs
Salaries	\$35,715
Benefits	\$13,572
Equipment	\$73,502
Services	\$16,885
Travel	\$2,137
Supplies	\$17,328
Permit Application Fees	\$600
TOTAL DIRECT COSTS	\$159,739
Indirect Costs @ 15%	\$23,961
TOTAL PROJECT COSTS	\$183,700

Table 2: Final project budget estimates.

A specific breakdown of the costs included under the "Equipment" category are in Table 3. These costs are associated only with Objective 1 (Increase irrigation efficiencies on agricultural lands). At the righting of this report, these are estimated costs. Again, the actual final costs may be found in the vouchers submitted to DOE and BPA for payment.

3-Phase Power - 4" PVC	\$ 2,332
3-Phase Power – Trenching	\$ 582
3-Phase Power – Trenching	\$ 366
3-Phase Power- PUD Fees	\$ 4,900
3-Phase Power- PUD Fees	\$ 12,700
Buried Mainline- Bedding, backfilling and pipe installation	\$ 5,300
Buried Mainline- PVC pipe	\$ 268
Buried Mainline- PVC Pipe, Adapter	\$ 804
Buried Mainline- Supplies	\$ 1,928
Buried Mainline- Supplies	\$ 5,717

¹ E-mail from Chris Hall (former staff of DOE) referencing a field excursion with Jeff Jones (US Timberlands) to Lick Creek on April 22, 2002. Conclusion was "There does not appear to be anything that can be done at this time to decrease sloughing of Lick Creek banks into the water."

1

Buried Mainline- Supplies	\$	2,572
Buried Mainline- Trenching	\$	3,564
Buried Mainline- Trenching	\$	100
Pump	\$	1,870
Pump	\$	11,480
Pump and Screen	\$	9,800
Pump and Screens	\$	7,167
Ring Well Components	\$	2,069
Total Favinment Fynance	4	72 502

Total Equipment Expenses \$ 73,502

Table 3: Breakdown of estimated equipment costs for Objective 1-Increase Irrigation Efficiencies on Agricultural lands.

Supplemental volume or appendices that contain detailed summaries of all data collected.

Appendix A

Quality Assurance Project Plan--Contact KCCD

Appendix B

Water Quality Data (on CD) and Quality Control and Quality Assurance Information--Contact KCCD

Appendix C

Temperature Data--Contact KCCD

Appendix A- Quality Assurance Project Plan

Teanaway River Basin Temperature and Suspended Sediment/Turbidity Monitoring Plan

Kittitas County Conservation District & Washington State Department of Ecology

Quality Assurance Project Plan

Anna Lael (KCCD) and Jane Creech (Ecology)

January 7, 2003

Approvals:

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1-31-03

Date

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Introduction

The Teanaway River, in Kittitas County, drains the upper reaches of the Yakima River on the east slope of the Cascade mountain range. The basin currently experiences high stream temperatures detrimental to threatened salmonids (steelhead and bull trout) as well as to spring chinook and resident trout. There are eight waterbodies in the Teanaway Basin identified on Washington State's latest 303(d) list as being impaired for temperature (Ecology, 1998). The Department of Ecology (Ecology) verified these listings during the summer of 1998, when data showed that the middle and lower basin exceeded water quality standards for water temperature (see Appendix A) in over 75% of the days monitored (July through September).

In 2000, a total maximum daily load (TMDL) technical evaluation was written by Ecology to address water temperatures in the Teanaway River Basin (Stohr, 2000), and the TMDL submittal (Irle, 2001) was accepted by USEPA Region 10 in January 2002. One of the major recommendations of the TMDL is to 1) conduct further water temperature monitoring to establish baseline levels, and to 2) conduct monitoring for suspended sediment and turbidity, both to establish a baseline and to identify major suspended sediment sources. This project will accomplish all these goals.

Project Description

Historical Information

Many reports (KCCD, 1998; Berg, 2001; Stohr, 2000; Conservation Commission, 2001) have indicated that for many years, the Teanaway River basin has experienced high summer water temperatures and high suspended sediment and turbidity levels particularly during spring runoff or storm events. In addition to these historical water quality findings, other comprehensive studies of water quality in the Yakima River Basin have also been completed (Joy and Patterson, 1997; KCCD, 2000; Joy, 2002).

Forestry practices

All of the forest stands in the Teanaway River Basin, below the Forest Service Boundary have been harvested at least once and many areas have been logged two or three times since 1903. Past logging practices have included the use of splash dams and the construction of railroads parallel to or in the streambeds themselves.

Agriculture and rangeland

The Teanaway Basin has been used for agriculture since the early 1900's. Beginning in 1920, Cascade Lumber leased land for cattle and sheep in the North Fork Teanaway Basin. The cattle herd ranged from 400 to several thousand through 1993. Today, approximately 230 head of cattle are raised in the North Fork basin with a small number of additional cattle grazing in the West Fork Teanaway Basin. Feed crops and hay are grown adjacent to the Teanaway and its

tributaries. Domestic water use is supplied by wells and irrigation is provided by surface water withdrawals.

<u>Fish</u>

Anadromous species that occur in the basin include spring-run chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*); resident species include brook (*Salvelinus fontinalis*), rainbow (*O.mykiss*), cutthroat (*O. clarki*), and bull trout (*S. confluentus*). Washington Department of Fish and Wildlife (WDFW) manages the Teanaway Basin primarily for anadromous species. Very low numbers of anadromous fish now reach the forks of the Teanaway.

Geology, soils and roads

Surface erosion occurs when soil from sufficiently steep slopes is exposed to precipitation and the subsequent overland flow can detach soil particles and eventually carry them to streams - where the typically fine-grained soil has the potential to impact water quality and fish spawning habitat. Inputs of fine suspended sediment to streams also affects stream temperature by contributing to the widening and shallowing of a stream which makes it more vulnerable to heating, due to solar radiation and a larger water surface to air interface. Suspended sediment sources in the basin include natural conditions, weather events, landslides, roads, and logging and agriculture practices.

Project Objectives

- 1. Characterize the Teanaway River basin for water temperature.
 - Evaluate the water temperature in the Teanaway River basin, to set baseline levels for future comparison.
 - Locate areas of greatest water heating, in an effort to begin reducing water heating.
- 2. Characterize the Teanaway River basin for suspended sediment (as total suspended solids [TSS]) and turbidity, in order to establish baseline levels.
 - Evaluate the suspended sediment in the Teanaway River basin.
 - Evaluate contributions from major tributaries.
 - Identify significant suspended sediment sources.

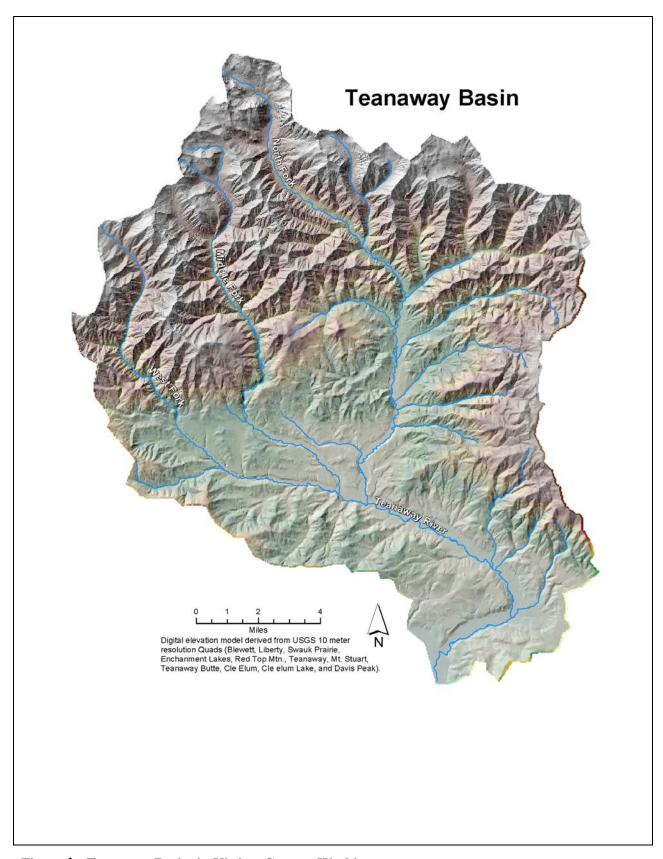


Figure 1: Teanaway Basin, in Kittitas County, Washington

Site

The Teanaway River Basin drains an area of 207 square miles and is located east of the Cascade crest near the town of Cle Elum, Washington. The Teanaway lies in the upper reaches of the larger Yakima River watershed, and is one of the major tributaries of the Yakima River. Topography and location of this Kittitas County watershed are displayed in Figure 1. Figure 2 displays the land use in the watershed.

The climate consists of warm, dry summers and cold, snowy winters. Annual precipitation ranges from 20 inches near the mouth of the Teanaway River (elevation 1800 feet) to 90 inches in the high mountains (elevation 6000 feet). Peak runoff events are of two kinds; rain-on-snow precipitation events between November and February and high flows associated with spring snowmelt in April and May. Streamflow information is available for the U.S. Bureau of Reclamation (USBR) gage located on the Teanaway River below the confluence of the three major forks. The gage is upstream of major irrigation diversions, and drains approximately 172 square miles. The 1971 – 1998 period of records show a peak flow of 8000 cfs and a low flow of 6 cfs, with an average annual peak of 1000 cfs and an average annual 7-day low of 15 cfs.

Major land uses (Figure 2) and ownership can generally be described by dividing the watershed into thirds. The upper one-third of the watershed lies in the Wenatchee National Forest and is managed by the USFS. Much of the middle one-third of the watershed is owned and managed by private timber companies with land adjacent to the Middle and North forks often in light agricultural or range land. The lower one-third of the watershed, below the West, Middle, and North forks, contains hay, feed crops and horses near the main stem and timber management in the surrounding hills.

Project Schedule

The comprehensive project schedule is based on the milestones noted below (Table 1). A more detailed water quality sampling schedule can be found in Table 2.

Table 1: Project schedule for the Teanaway Basin Monitoring Program

Water Quality Sampling	July 1, 2002 through September 30, 2004
Laboratory Analyses Complete	December 31, 2004
Interim Report	February 28, 2005
Draft Final Report	August 31, 2005
Final Report	October 31, 2005

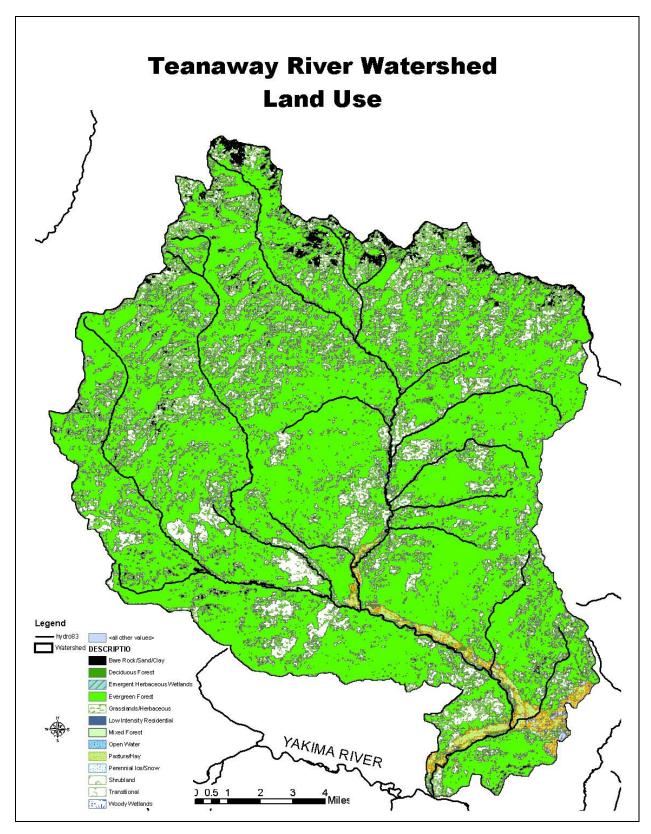


Figure 2: Teanaway Basin Land Use Map. Derived from DNR data layer.

Study Design

Temperature loggers will be installed, and water samples will be collected, using approved protocols (see Appendices B and C) at carefully selected points in the Teanaway Basin. Velocity, flow, and stage (depth) will be evaluated using state-of-the-art equipment. Field analyses will be carried out by trained staff. Laboratory analyses will be completed at an Ecology-accredited laboratory. Analytical methods approved by the U.S. Environmental Protection Agency (EPA) will be used for all laboratory analyses.

Site locations are based on several factors including year round accessibility; land use; anecdotal history of water quality (e.g. Lick Creek); and analysis of FLIR (forward looking infrared) stream temperature data from the Forest Service collected in 2001 on all three forks of the Teanaway and the mainstem. Establishment of background sites for suspended sediment and turbidity will be pursued.

GIS will be used extensively in comparing and analyzing land use in the individual areas that drain to each sample site location. The land use analysis may be helpful for interpreting the temperature, suspended sediment and turbidity (levels) data collected over this two year sampling program.

Monitoring Schedule

<u>Temperature</u>

Placement of Loggers: Temperature loggers will be installed at eight sites in early summer (late June or early July) and removed in the fall, probably late October. Most temperature loggers will be placed in the water, with one temperature logger dedicated to measuring ambient air temperature. See Table 3 for location of temperature loggers. Data from these loggers will be downloaded at least monthly.

Quality Assurance Checks for Temperature: Whenever temperature loggers are downloaded, or when suspended sediment samples are collected, a red liquid thermometer will be used to check both air and water temperature.

Suspended Sediment and Turbidity

Sample Collection: Samples will be collected biweekly at 10-13 locations during each sampling event from November 1, 2002 through September 30, 2004.

Storm/Peak Run-off Events: Samplers will also collect data during at least four excursions during storm events and/or peak run-off conditions. The purpose of these sampling excursions will be to assess the water quality during periods of extreme high water, with associated suspended sediment movement. All sampling procedures and protocols will be the same for sample collection and flow data collection during storm and run-off events as during all other sampling events.

General Scheduling: Each water quality field survey will take one day. This schedule is reflected in Table 2, below – note that all days listed are Mondays. The actual schedule may vary slightly due to weather restrictions or other conflicts. Scheduling of sampling times (that is, the time of day that a sample is collected at a given location) will be organized in such a manner that sampling times will vary from one sampling event to the next. Additionally, the sequence of sample collection will occur in a manner most expedient for the KCCD.

Table 2: Water quality sampling schedule for Teanaway temperature/suspended sediment baseline evaluation project.

2002 Sample Dates	2003 Sample Dates	2004 Sample Dates
November 4, 2002	January 13, 2003	January 12, 2004
November 18, 2002	January 27, 2003	January 26, 2004
December 2, 2002	February 10, 2003	February 9, 2004
December 16, 2002	February 24, 2003	February 23, 2004
December 30, 2002	March 10, 2003	March 8, 2004
	March 24, 2003	March 22, 2004
	April 7, 2003	April 5, 2004
	April 21, 2003	April 19, 2004
	May 5, 2003	May 3, 2004
	May 19, 2003	May 17, 2004
	June 2, 2003	May 31, 2004
	June 16, 2003	June 14, 2004
	June 30, 2003	June 28, 2004
	July 14, 2003	July 12, 2004
	July 28, 2003	July 26, 2004
	August 11, 2003	August 9, 2004
	August 25, 2003	August 23, 2004
	September 8, 2003	September 6, 2004
	September 22, 2003	September 20, 2004
	October 6, 2003	
	October 20, 2003	
	November 3, 2003	
	November 17, 2003	
	December 1, 2003	
	December 15, 2003	
	December 29, 2003	

Field analytical data will be collected and staff gage readings will be taken when samples are collected. Flow readings will be taken as time allows between sampling events in order to develop flow rating curves for each site.

Sampling Locations

Water samples, field analytical data and flow data will be regularly collected at 11 sites. One of those eleven sites (Lick Creek) is dry for a significant portion of the year and many of the upper

sites (Middle, Indian, and Jack Creek) may well freeze over for a portion of the winter. There are two additional sites that may be sampled, particularly in a high runoff or storm event situation. Those sites are Stafford Creek and Beverly Creek. During the winter months, those sites are inaccessible and therefore not a regular part of the sampling program. At two additional sites, only temperature data will be collected, for a total of 15 data collection sites. These sites are listed in Table 3 and displayed graphically in Figure 2. Of the 15 data collection sites, there are 3 sites on the mainstem of the Teanaway River, 5 sites on the forks of the Teanaway River, and 7 sites on tributaries. At least two sample collection sites may be considered background sites for the purposes of assessing turbidity data.

Field and Laboratory Analyses

Measurements to be taken in the field include air and water temperature, turbidity, velocity, stage and stream discharge. Samples collected for laboratory analysis will be sent to the U.S. Bureau of Reclamation's Pacific Northwest Regional Laboratory in Boise, Idaho ("USBR Lab"), which is accredited by Ecology (see Appendix D).

Table 4 summarizes the parameters analyzed in the field and laboratory, as well as appropriate methods, precision, detection limit and holding times. All samples collected will be analyzed for all parameters listed in Table 4.

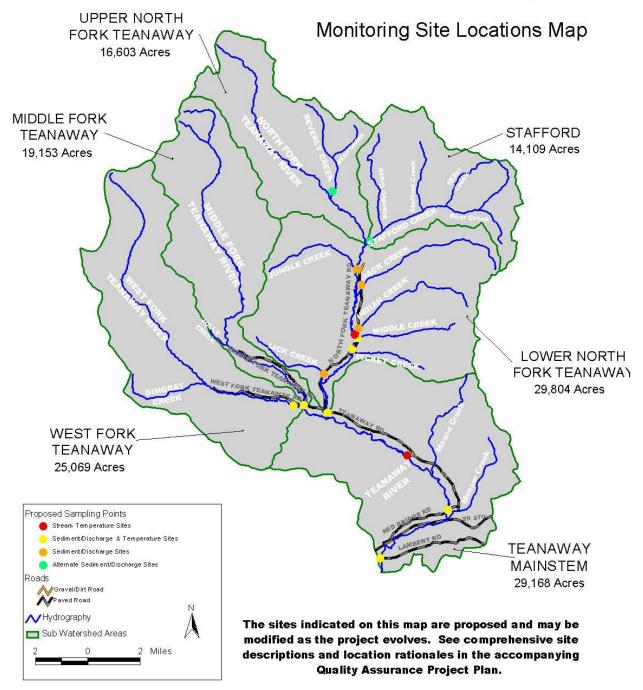
Complete discussions of appropriate sampling and analytical procedures can be found in the "Sampling Procedures" and "Analytical Procedures" sections of this document, as well as in the Appendices. Specific protocols for sample collection, preparation and preservation will be strictly followed (see Appendix B). All samples collected for laboratory analysis will arrive at the laboratory and undergo processing well within the holding times in Table 4 (i.e., within 48 hours of sample collection, the shortest holding time).

Table 3. Sampling locations for Teanaway temperature/suspended sediment study. (Colors correspond to colors on map on following page).

Site No.	Station Name	Station Location (Temperature; Suspended sediment/Discharge)	Storet Nos.	Temp. Data Logger	Suspended sediment & Turbidity Sampling	USBR Gage Station	Staff Gage	Latitude	Longitude
	Mainstem Teanaway at	RB directly Upstream of pumping	YAV	77	X	77		450 101 20 511131	120° 50'
1	Lambert Bridge	station; Upstream side of the Bridge	240	X		X		47° 10′ 30.51" N	09.84" W 120° 46'
2	Mainstem Teanaway at Red Bridge	LB on upstream side of bridge; Upstream side of bridge	YAV 238	X	X			47° 12' 05.27" N	53.05" W
	Mainstem Teanaway at	2 nd Engineered Rock barb on left bank	238	Λ				4/ 12 03.2/ N	120° 48'
3	Violet Burke's Property	of river;		X				47° 13' 52.92" N	51.15" W
4	West Fork Teanaway at Mouth	Near rock face on south bank of West Fork; Upstream of first bridge across the West Fork	YAV 236	X	X	X		47° 15' 25.08" N	120° 53′ 56.55" W
5	Middle Fork Teanaway at West Fork Teanaway Road	On LB upstream of bridge (<i>Note: This site shared with USFS for quality control</i>); Upstream of bridge	YAV 234	X	X			47° 15' 31.90" N	120° 53′ 51.42" W
6	North Fork Teanaway at Mouth	On RB near junction of West Fork Rd.; Upstream side of 1 st bridge across North Fork	YAV 232	X	X			47° 15' 26.60" N	120° 52′ 48.29" W
7	North Fork Teanaway at Dickey Creek	On RB, ~500 feet downstream of second North Fork bridge; Upstream side of bridge	YAV 228	X	X			47° 17' 17.11" N	120° 51′ 33.15" W
8	North Fork Teanaway between Middle and Indian Creeks	On LB in pool just upstream from Middle Creek mouth		_X_				47° 17' 49.16" N	120° 51' 25.39" W
9	North Fork at Camp Lake Road (USFS Road 9701)	Upstream side of bridge just above mouth of Jungle Creek	YAV 220		X				
10	Lick Creek @ NF Teanaway Road	Upstream side of culvert (this site is dry much of the year)	YAV 230		X				
11	Middle Creek @ NF Teanaway Road	Upstream side of culvert	YAV 226		X				
12	Indian Creek @ NF Teanaway Road	Upstream side of culvert	YAV 224		X				
13	Jack Creek @ NF Teanaway Road	Upstream side of culvert	YAV 222		X				
14	Stafford Creek at USFS Road 9737	Upstream side of bridge			X				
15	Beverly Creek at USFS Road 9737	Upstream side of bridge			X				

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Teanaway River Water Quality Monitoring



This map was created by the KCCD on October 24, 2002. Revised November 12, 2002.

Figure 3: Location of sampling sites in Kittitas County

Table 4. Summary of field and laboratory methods with precision and reporting limits.

Parameter	Method and Reference ^a	Precision Limit	Reporting Limit	Holding Times
Field Measurements				
Velocity	Marsh-McBirney flow meter - Ecology, 1993	less than 20% RPD ^b	0.05 feet/second	NA ^c
	Red liquid thermometer - Ecology, 1993 (modified in Appendix E)	± 0.1° C	0.1° C	NA
Water Temperature	HOBO Water Temp Pro® temperature data logger - Appendix C	± 0.2° C	0.1° C	NA
Air Temperature	Red liquid thermometer - Ecology, 1993 (modified in Appendix F)	NA ^d	0.1° C	NA
Turbidity	EPA 180.1 (KCCD owned Hach 2100 P Turbidimeter)	15% RPD ^e	1 NTU	
Laboratory Measureme	ents			
Turbidity	EPA 180.1	15% RPD ^e	1 NTU	48 hours
Total Suspended Solids	EPA 160.2	15% RPD	1 mg/L	7 days

a Methods and References:

Appendices C, E and F: See appropriate appendices of this document Ecology, 1993: Washington State Department of Ecology, 1993 EPA: U.S. Environmental Protection Agency, 1983

- b RPD = relative percent difference
- c NA = not applicable, all field measurements will be taken immediately, on-site
- d NA = not applicable, no replicate measurements taken of air temperature
- e RPD refers to total relative percent difference, which includes both lab and field variability.

Sampling and Analytical Procedures

Sampling Procedures

As appropriate, laboratory protocols from the USBR Lab will be incorporated into procedures for sample collection, preservation and shipping. Additionally, staff will adhere to standard field methods (USGS and other) for the collection of water samples, flow, and for the deployment of data recording equipment. Samples will be sent to the laboratory in the most expeditious manner, in order be taken to ensure that all samples are analyzed within appropriate holding times. Generally, samples will be collected using either an integrated sampler or directly into a one-liter sample bottle (i.e., a grab sample). Specific procedures for collection, preservation, and handling of laboratory samples are outlined in Appendix B of this document.

Analytical Procedures

Field Analyses

As noted previously, measurements to be taken in the field include: velocity, stage and stream discharge, and water and air temperature. Specific analytical procedures for each parameter are discussed below.

Stage, Velocity and Discharge: Instantaneous velocity data will be collected using a Marsh-McBirney water current meter per Ecology protocols for these procedures (Ecology, 1993). Flow data from U.S. Bureau of Reclamation (USBR) flow gages will be used where available, or calculated from these data. Staff gages will also be installed at all sampling sites where installation is possible; staff gages will have a reporting limit of no more than 0.02 feet.

Discharge information will be obtained at each sampling location to provide suspended sediment loading information for the irrigation season. Wherever possible, flow rating curves will be developed using a combination of instantaneous flow, water level data logger information and/or creek height reference point measurements. Project personnel will then use the flow rating curves, and either staff gage readings or level logger information, to determine stream discharge on a regular basis. Instantaneous flow measurements will be taken at intervals to check the rating curves and to cover the full range of seasonal flows. In the few places where it is not possible to develop flow rating curves, flow will be determined by using a flow meter at the time of sample collection.

Water Temperature: Water temperature data will be collected using a red liquid thermometer and HOBO Water Temp Pro® data loggers. Temperature data collected with the red liquid thermometer will be collected in accordance with Ecology protocols for these procedures (Ecology, 1993), as modified in Appendix E. Temperature data collected with the HOBO data loggers will follow manufacturer protocols for this procedure, as modified in Appendix C.

Air Temperature: Air temperature data will also be collected using a red liquid thermometer. One thermometer will be reserved specifically for the measurement of air temperature and will be clearly marked to differentiate it from the thermometer(s) used for water temperature. Data collection will follow the protocols in Appendix F.

Turbidity: Turbidity measurements will be conducted by KCCD using a Hach 2100P portable turbidimeter. Data collection will follow the protocols in Appendix G. These protocols were developed by the Department of Ecology's Central Regional office.

Laboratory Analyses

All laboratory analyses will be carried out at the USBR Lab, in accordance with their laboratory quality assurance plan (USBR, 1989). All laboratory analyses will be made using EPA standard laboratory methods (Table 4).

Data Management and Quality Control

Data Quality Objectives

Definitions of the following concepts may be found in the Glossary, Appendix G.

Bias: By strictly following protocols for sample collection and field analysis, and by calibrating meters before all sampling excursions, it is expected that only minimal bias will be introduced in the field. Calibration of meters will also be checked during and after sampling events. Calibration standards for each piece of equipment that can be calibrated are listed in the appendices, either directly or by reference to the operator manual for that equipment. To further reduce bias introduced in the field, walkway planks will be added where possible to ensure that integrated samples are taken at all sites where the water is deep enough for this type of sample (see Appendix B).

Precision: Replicate samples (10% of total samples collected) will help assess precision. Precision limits for laboratory analyses of replicate samples are the combination of typical analytical and field sampling variances. Precision limits for analyses performed under this grant appear in Table 4, and were determined by comparing a) the mean relative percent difference (RPD) of 1999 laboratory duplicates of samples with b) the RPD of KCCD field replicates collected in 2000 & 2001. Table 5, below, shows the data used to make this determination. At levels close to the detection limit, the analytical RPD may become artificially high – for instance, with turbidity replicates of 1 and 2 NTU, the RPD is 67%. In these cases, the high RPD will become acceptable, and will be discussed in the data assessment section of the final report.

Table 5: Estimates of laboratory and field precision.

{PRIVATE}Parameter	1999 Laboratory Duplicates (Mean % RPD)	Number of Records	2000 & 2001 KCCD Field Replicates (Mean % RPD)	Number of Records
Total Suspended Solids	11.06	204	8.6%	37
Turbidity	1.06	202	5.0%	37

Representativeness: Both the sampling schedule and the monitoring site location should accurately describe the conditions to be evaluated by this project. Samples will be collected every two weeks during the project period in order to characterize conditions. Samples on larger waterbodies will be collected using an integrated sampler to represent width and depth variations. Smaller waterbodies will be grab-sampled in consistently well-mixed locations.

Completeness: Weather or unforeseen equipment failure are the main factors that could possibly affect completeness, and these factors will be anticipated to the maximum extent possible. All sampling surveys are expected to be completed with usable high quality data. The sampling staff is well trained, and all sampling excursions will be well organized. Transportation of samples to the laboratory is consistent and well organized as well, with backup plans in case of emergency.

Comparability: Quality assurance (QA) checks for water temperature between the KCCD and the US Forest Service will occur regularly by comparing data collected from data loggers at the Middle Fork Teanaway. QA checks for suspended sediment and turbidity between the KCCD and the Kittitas County Water Purveyors (KCWP) will occur every fourth week (every other regular KCCD sampling event). The samples will be collected one right after the other at the Lambert Road location. The KCCD and KCWP will each take two QA samples at the Lambert Road site, and each group will then ship their samples to the laboratory for analysis. The QA check samples are important to ensure data comparability between the entities, as they intend to share data in the future. Data will be reviewed in context with the data set and methods and will be considered compatible if the quality assurance sample pair results are within the precision limits for each parameter. If data appears incompatible, sampling and shipping methods will be reviewed.

Quality Control Procedures

Replicate samples will be collected randomly at 10% of the sites at every sampling event, and will help provide information regarding precision. Flow-metering and the reading of staff gages will be replicated 10% of the time as well. Information regarding total variation for field sampling and analytical variation will also be provided. The laboratory will also use standard quality control procedures (USBR, 1989).

Samples will be collected according to standard procedures (see Appendix B). Wherever possible, samples will be depth and width integrated at three or more points on the cross-section of wider streams; samples will be collected with an integrated sampler. On smaller creeks where it is not possible to use the integrated sampler, grab samples will be collected mid-channel and mid-depth directly with the laboratory-cleaned sample bottles.

Samples will be collected with appropriately cleaned sampling equipment. A liter cubitainer will be used to ship water samples for all analytes. Sample containers will be labeled with STORET numbers, date, time of sample collection, and name of person collecting the sample. After samples are collected, they will be placed in coolers with adequate ice to cool the samples to 4° C, and ice will be added as needed to maintain the 4° C. The coolers will then be shipped by UPS, leaving Ellensburg by 4 PM the same day, and will be received at the laboratory the following morning, well within minimum holding times. The laboratory will verify 4° C and record arrival time when coolers are received. If the holding time should be exceeded, the laboratory will notify KCCD.

Data Handling Procedures

Collection and management of data in the field will begin with field notebooks and data sheets to record all data and observations regarding the sampling and monitoring. An entry will be made at each sampling event. Each entry should include the date, time of sample collection, general weather conditions, staff gage reading (if collected) and any other pertinent information about the site. All collected data will be summarized through computer software programs such as Excel and ArcView (geographic information systems (GIS)). The field notebooks will be kept at the KCCD office. All computerized data downloaded from the field will be copied to computers in the office. Office computers are backed up biweekly onto recordable compact discs, which are kept off premises.

Standard laboratory procedures for analytical data reduction, review and reporting will be followed. Laboratory personnel will immediately inform the KCCD of any problems with sample shipment conditions, holding times, or analyses. Data will be sent from the USBR Lab to KCCD electronically, in standard file format, with paper copies available from the laboratory upon request. Lab and field analytical data will be matched with sample times and locations, and transferred to an Excel spreadsheet. Data will be screened for questionable values and problems, which will then be immediately discussed with the laboratory and, if necessary, sample collection and handling methods will be reviewed.

Data Assessment Procedures

The identification of sources of suspended sediment or land areas contributing to the impairment of water quality in the Teanaway Valley will result from analysis of the water quality data. GIS mapping of water quality results will assist with this analysis as well.

Where applicable, field and laboratory analyses will be compared to state water quality criteria (Appendix A). Turbidity data will be compared to an appropriate turbidity standard. Suspended sediment loading will be calculated (TSS concentration multiplied by flow) for all waterbodies sampled. Laboratory and field analytical results from the storm and run-off event sampling excursions will not be included in computations of means. Storm and run-off event data will be considered separately.

All data collected during the project will be available in the final report or upon request as a technical supplement. All data will be formatted in accordance with Ecology's Environmental Information Management (EIM) System data reporting protocols.

Project Organization and Budget

Personnel and Responsibilities

The roles and responsibilities of staff involved in this project are provided below:

Anna Lael, District Manager, Kittitas County Conservation District. (509) 925-8585, X4; <u>annalael@wa.nacdnet.org</u>. Project lead. Directs sample collection and data analysis.

Sara Bull, Financial Manager, Kittitas County Conservation District. (509) 925-8585, X4; sara-bull@wa.nacdnet.org. Manages vouchers, etc; assist with sample collection.

Jill Gallie, Resource Technician, Kittitas County Conservation District. (509) 925-8585, X4; <u>jill-gallie@wa.nacdnet.org</u>. Sample collection, data logger installation and downloading.

Rusty Gigstead, Resource Technician, Kittitas County Conservation District. (509) 925-8585, X4; rusty-gigstead@wa.nacdnet.org. Assist with sample collection.

Suzanne Wade, GIS Specialist, Kittitas County Conservation District. (509) 925-8585, X4; suzanne-wade@wa.nacdnet.org. Creates GIS maps for project, helps compile and evaluate field data.

Carol Ready, Water Quality Specialist, Kittitas County Water Purveyors. (509) 925-6158; carol.ready@kcwp.org. Collect concurrent samples with KCCD for quality control and assurance purposes.

Chris Coffin, Environmental Assessment Program, Washington State Department of Ecology. (509) 454-4257, ccof461@ecy.wa.gov. Reviews and approves QAPP for completeness. Provides technical advice to KCCD as needed.

Joe Joy, Environmental Assessment Program, Washington Department of Ecology. (509) 407-6486, <u>jjoy461@ecy.wa.gov</u>. Reviews and approves QAPP for completeness. Provides technical assistance to KCCD as needed.

Jane Creech, Central Regional Office, Washington Department of Ecology. (509) 925-7766, jton461@ecy.wa.gov. Assists in defining project objectives, scope, and study design. Assists with QAPP. Provides guidance if needed.

Laboratory Budget

The following is the estimated budget for laboratory services for this project. This budget covers total sampling and analysis expenditures for grant (June 1, 2002 to December 31, 2005). This budget is only an estimate and will be revisited often and modified as necessary.

Table 6: Estimated laboratory budget.

	IRR	IGATION	SEASO	N SAMI	PLING		
Parameter	Samples Per Event*	Event Replicates (10%)	Total Samples Per Event	Number of Events	Total Samples (Life of Grant)	Cost Per Sample	Total Cost Per Parameter
Total suspended solids	9	1	10	53	530	\$10	\$5,300
Turbidity	9	1	10	53	530	\$10	\$5,300
TOTAL	18	2	20	53	1,060	\$10	\$10,600

^{*}This takes into consideration Lick Creek having flow only 50% of the time and Middle, Indian, and Jack Creeks freezing solid 25% of the time. It is also possible that the North Fork Teanaway at USFS 9701 and the West Fork may be frozen during a portion of the sampling season. The budget and number of sample events will be re-evaluated after the first 6 months to ensure the estimates match reality.

•	STORN	M & RUN	OFF EVI	ENT SA	MPLING	I T	
Parameter	Samples Per Event	Event Replicates (10%)	Total Samples Per Event	Number of Events	Total Samples (Life of Grant)	Cost Per Sample	Total Cost Per Parameter
Total suspended solids	13	1	14	4	56	\$10	\$560
Turbidity	13	1	14	4	56	\$10	\$560
TOTAL	26	2	28	8	112	\$10	\$1,120
			·		·		

TOTAL FOR ALL REGULAR		
SAMPLING	1,172	\$11,720

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Appendix A: Water Quality Standards

All sample sites for this project are located in Class AA (exceptional) and Class A (excellent) waterbody segments. Class A fresh water quality standards and characteristic uses (WAC 173-201 A) are listed below. In the Teanaway River basin, all waters on US Forest Service lands are Class AA, and all waters outside the USFS lands are Class A.

	Class AA	Class A
General	Shall markedly and uniformly exceed the requirements	Shall meet or exceed the requirements for all, or
Characteristic	for all, or substantially all uses.	substantially all uses.
Characteristic Uses	Shall include, but not be limited to, the following	
	domestic industrial, and agricultural water supply;	
	stock watering; salmonid and other fish migration,	
	rearing, spawning, and harvesting; wildlife habitat;	
	primary contact recreation, sport fishing, boating, and	
	aesthetic enjoyment; and commerce and navigation.	
Water Quality Criter		
Fecal Coliform	Shall not exceed a geometric mean value of 50	Shall not exceed a geometric mean value of 100
	organisms/100 mL, with not more than 10% of	organisms/100 mL, with not more than 10% of
	samples exceeding 100 organisms/ 100 mL.	samples exceeding 200 organisms/ 100 mL.
Dissolved Oxygen	Shall exceed 9.5 mg/L.	Shall exceed 8.0 mg/L.
Total Dissolved Gas	Shall not exceed 110% saturation.	Same as AA.
Temperature	Shall not exceed 16.0° C due to human activities.	Shall not exceed 18.0° C due to human activities.
	When conditions exceed 16.0° C, no temperature	When conditions exceed 18.0° C, no temperature
	increase will be allowed which will raise the receiving	increase will be allowed which will raise the receiving
	water temperature by greater than 0.3°C. Increases	water temperature by greater than 0.3°C. Increases
	from non-point sources shall not exceed 2.8°C.	from non-point sources shall not exceed 2.8°C.
pН	Shall be within the range of 6.5 to 8.5 with a man-	Shall be within the range of 6.5 to 8.5 with a man-
	caused variation with a range of less than 0.2 units.	caused variation with a range of less than 0.5 units.
Turbidity	Shall not exceed 5 NTU over background turbidity	Same as AA.
	when the background turbidity is 50 NTU or less, or	
	have more than a 10% increase in turbidity when the	
	background is more than 50 NTU.	
Toxic, Radioactive, or	Shall be below concentrations which have the	Same as AA.
Deleterious Material	potential singularly or cumulatively to adversely affect	
	characteristic uses, cause acute or chronic conditions	
	to the most sensitive aquatic biota, or adversely affect	
	public health (see WAC 173–201A–040 and 173–	
	201A–050 regarding criteria for specific substances).	
Aesthetic Value	Shall not be impaired by the presence of materials or	Same as AA.
	their effects, excluding those of natural origin, which	
	offend the senses of sight, smell, touch, or taste.	

Appendix B: Protocols for Collection, Preservation and Handling of Laboratory Samples

Representativeness is a measure of the extent to which the measurements obtained (water quality parameters) actually depict the true environmental condition being evaluated. The goal of these protocols is to make each sample as representative as possible of the waterbody from which it is taken.

Sample Containers

Sample containers supplied by the laboratory are 1-liter polyethylene "cubitainers" with plastic lids.

Cleaning and Rinsing Protocols

Sampling devices (e.g., the nozzle, lid and sample bottle on an integrated sampler) will be thoroughly cleaned with a suitable detergent (e.g., Alconox) and rinsed prior to each sampling excursion. These items will then be placed in a sealed plastic bag until their next use. These sampling devices will also be rinsed at least three times with sample water before <u>each</u> sample is collected.

Sampling equipment will be rinsed with deionized water before going from areas of high concentration to areas of low concentration. In other words, when one has collected samples from waters containing high concentrations of pollutants, the sampling equipment will be thoroughly rinsed with deionized water before collecting samples from waters that have low concentrations of pollutants.

A plastic funnel, which may be used occasionally to transfer samples from one vessel to another, will also be washed and rinsed as necessary in the above manner. The funnel will be kept in a sealed plastic bag between uses.

The cubitainers will be rinsed three times with stream water immediately prior to filling. When rinsing these containers, be sure that no particles remain in the sample containers after rinsing.

Grab Sampling

In low-flow water (i.e., velocity is less than 1.5 ft/s) or in shallow water where a depth-integrating sampler cannot be submerged, a representative sample can usually be obtained by immersing a hand-held open bottle (grab sample) in the center of flow with the mouth of the bottle directed toward the current. A grab sample should never be taken when it is possible to obtain depth-integrated samples. In natural streams when velocity is greater than 1.5 ft/s, suspended sediment normally has a higher concentration near the streambed than near the surface. The bias introduced by grab sampling in this situation can be considerable (Shelton, 1994).

Caution must be taken to preserve sample representativeness while grab sampling. When sampling in shallow water, contamination can also occur by sampling too close to the bottom and disturbing bottom sediments.

Grab samples can be collected in any clean vessel, preferably with a wide mouth for expediency. A basic grab sampling procedure includes the following:

- 1) Step into center of stream, and wait for disturbed sediment to clear.
- 2) Remove the lid of the sample container, and hold lid with free hand.
- 3) Facing upstream, quickly submerge the sampling vessel below the surface, in the center of flow with the mouth of the bottle directed toward the current.
- 4) Replace lid on bottle.

A sample bottle can also be attached to an extendable rod, and filled in much the same manner as above.

Sampling Using an Integrated Sampler

The term "integrated sampler" includes both a hand-held integrated sampler, such as the DH-81, or a suspended sampler, such as the DH-76. The integrated samplers consist of a cap and nozzle attached to a one-quart glass bottle, which is then attached to either a rod (in the DH-81) or a suspension device (DH-76) to lower the sampler to collect samples.

The equal-width-increment (EWI) sampling method is the integrated sampling procedure recommended by the USGS. The EWI method requires equal spacing of a number of verticals across a cross section (transect) of the stream and an equal transit rate, both upward and downward, in all verticals. The stream width is divided into a number of equal-width intervals. At least three intervals will be used per transect.

There will be one transect per site. Most transects will be located on one side of a bridge or walkway. In a few cases, the ends of the transects will be permanently marked on both banks of the waterbody.

Samples from all verticals will be accumulated in the same bottle. The sampling goal in each case will be to 1) sample all verticals, using the same transit rate for all verticals, and 2) fill the bottle to between three-quarters full and almost full (after sampling, there will be some headspace left to ensure that overfilling has not occurred). If overfilling of the bottle occurs, the bottle will be emptied and the EWI stations will be resampled. Overfilling can cause secondary circulation and enrichment of heavy particles, resulting in a biased sample (Shelton, 1994).

A basic integrated sampling procedure includes the following:

- 1) After removing the lid from a cubitainer, rinse the cubitainer three times with stream water. Be sure no particles remain in the cubitainer after final rinse. Replace the lid.
- 2) Rinse these items three times using stream water: the nozzle, lid and sample bottle from the suspended sampler that you will be using, as well as the funnel if you intend to use it. Be sure no particles remain in the sample bottle after final rinse.
- 3) Select either a) or b) below:
 - a) If you can wade into the stream, step into the center of the stream holding the hand-held integrated sampler, and sample upstream of any suspended sediment that may result from stepping into the stream, OR
 - b) <u>If you cannot wade into the stream</u>, position yourself (on a walkway, bridge, or other permanent support device) over the center of the first vertical, holding either the handheld or suspended integrated sampler.
- 4) Lower the integrated sampler into the stream at a consistent transit rate until you almost touch bottom, and raise the sampler at the same transit rate.
- 5) Look at the volume of sample water in the bottle. If the volume of water in the bottle is more than should be there proportionally (i.e., if you have three verticals, the sample bottle should be between 1/4 and 1/3 full at this point), empty the sample bottle and start again. Otherwise, continue to the next step.
- 6) Move to the next vertical, and repeat steps 4 and 5 until all verticals have been sampled.
- 7) When all verticals have been sampled, and if bottle is between 3/4 and almost full, careful remove the sample bottle from the integrated sampler. (If no headspace is left in the sample bottle, empty the sample bottle and start over). Remove the lid from the cubitainer, and pour the sample into the cubitainer (using the funnel if necessary), periodically stopping to swirl the integrated sample bottle to re-suspend any particles left in this bottle. As needed, a portion of the sample may be poured back into the integrated sample bottle to again resuspend particles to pour into the cubitainer. When finished, all of the sample must be in the cubitainer.

8) Replace cap on cubitainer.

High-Flow Sampling: If the velocity of the stream is so great that the suspended sampler (DH-76) is pulled downstream and cannot be lowered in the vertical or the combination of depth and velocity cause the sampler to overfill, alternate sampling methods are necessary. The number of sampling verticals should be kept to a minimum during periods of storm runoff when the stage is rapidly changing and it is necessary to collect a large number of samples from several locations within a relatively short period of time. Under these conditions, collect the samples at a reduced number of verticals at each site and document the circumstances and number of verticals on the field notes. It is most important to carefully document the exact procedure used during high-flow sampling, indicating what is differing from a "typical" sampling procedure (Shelton, 1994).

Sample Preservation and Handling

Immediately after sampling, water samples will be placed on ice, cooled to 4° C, and stored in closed coolers. The coolers will maintain the 4° C during the remainder of the sampling excursion; a thermometer will be kept in the coolers at all times to verify 4° C in the field. Samples will be transported at the end of the day to arrive at the lab by the following morning. The laboratory will verify the temperature of the coolers and the time of receipt of coolers. The KCCD will be notified if either desired sample temperature or holding times are exceeded.

Safety During Sampling

Individuals who collect water samples from bridges and on the margins of the roadway should always follow safety precautions during sampling events. Where appropriate, vehicle flashers should be turned on and traffic cones placed away from the vehicle to warn oncoming traffic. Samples will not be collected if personal safety is questioned.

Safety precautions should also be taken (where appropriate) when sampling during storm events or other high water sampling events. For instance, walkway planks may become unsafe during high flows. Again, samples will not be collected if personal safety is questioned.

Appendix C: Protocols for Measurement of Water Temperature Using Temperature Data Loggers (HOBO Water Temp Pro®)

HOBO Water Temp Pro® temperature data loggers will be used to collect continuous water temperature data. The operator will follow both the manufacturer's protocols found in the instruction manual, as well as the following modifications. Prior to initial operation, operators should read all operating instructions and supplemental documentation accompanying the meter. A copy of the operator's manuals for these pieces of equipment is attached.

Selecting Channels and Resolutions

The factory default is high-resolution mode for temperature measurements, and each time the logger is launched, the software defaults to the parameters specified the last time the logger was launched. High-resolution mode will always be selected, as it dramatically improves the temperature resolution and accuracy. High-resolution mode also uses twice as much memory, so it will be necessary to download data more frequently.

Installation

Underwater: Securely fasten the logger to a stationary underwater object, at least one foot below lowest low water level and out of direct sun.

Above-Water Installation: Securely fasten the logger to a stationary object and is in the shade throughout the day.

Calibration and Maintenance

HOBO data loggers are factory calibrated, and the calibration must be re-set at the factory. However, the calibration can be checked (as follows) and will be checked at least annually.

Calibration Check: Check calibration at least annually. Make a mixture of crushed ice and water and put it in an insulated container. Launch the logger and put its external sensor into the crushed ice solution. You can also take the whole logger (with the external sensor), and put in a two sealed plastic bags, one inside the other. Finally, put the container into a refrigerator. The water temperature will then be nearly 0° C since the ice will be melting very slowly. Let it record for an hour or so and then read it out. The recorded temperature should stabilize around 0° C.

Tune-Ups: The logger must be sent to the factory for a "tune-up," which includes calibration, installation of a new O ring and a new battery, and re-testing. The HOBO data loggers will be sent back to the Onset Corporation factory every two years for tune-up procedures.

Quality Assurance Checks: Water temperature data will be downloaded from all HOBOs within the first month of installation. This initial HOBO data will be compared with the data from the red liquid thermometers – i.e., at each site where a HOBO is installed, the HOBO and red liquid thermometer readings will be compared to check HOBO accuracy. If the difference between data points from the red liquid thermometer and the HOBO is more than 0.2° C, then the HOBO at that site will be sent back to the factory for a "tune-up." After the initial check, the HOBOs will then be downloaded about every three months, and this data again compared with data from the red liquid thermometers. As before, if the difference between data points from the red liquid thermometer and the HOBO is more than 0.2° C, then the HOBO will be repaired.

Appendix D: Laboratory Accreditation

The U.S. Bureau of Reclamation's Pacific Northwest Regional Laboratory in Boise, Idaho is currently accredited by Ecology for analysis of total suspended solids (TSS) and turbidity. The approved analytical methods for these parameters are listed on the accreditation on the following pages. Accreditation will be renewed on schedule.

Scope of Accreditation

Bureau of Reclamation - PN Regional Lab,

Boise, ID,

is accredited by the State of Washington Department of Ecology to perform analyses for the parameters listed below using the analytical methods indicated. This Scope of Accreditation applies to non-potable water analyses only. Accreditation for all parameters is final unless indicated otherwise in a note. Accreditation is for the latest version of a method unless otherwise specified in a note. EPA refers to the U.S. Environmental Protection Agency. SM refers to American Public Health Association's publication, Standard Methods for the Examination of Water and Wastewater, 18th edition, unless otherwise noted. ASTM stands for the American Society of Testing and Materials. PSEP stands for Puget Sound Estuary Program. Other references are detailed in the notes section.

Parameter Name	Reference	Method Number	Notes
Alkalinity, Total	EPA	310.1	1
Ammonia	EPA	350.3	
Biochemical Oxygen Demand, BOD/CBOD	EPA	405.1	1
Chemical Oxygen Demand (COD)	EPA	410.2	1
Chloride	EPA	325.2	1
Chlorophyll	SM	10200 H(2)	1
Fluoride	EPA	340.2	1
Nitrate + Nitrite	EPA	353.2	
Nitrogen, Total Kjeldahl	EPA	351.2	
Orthophosphate	EPA	365.1	1
Phosphorus, Total	USGS	I-4600-85	
Silica, Dissolved	EPA	370.1	1
Solids, Total Dissolved	EPA	160.1	1
Solids, Total Suspended	EPA	160.2	
Specific Conductance	EPA	120.1	
Sulfate	EPA	375.4	
Total Organic Carbon	EPA	415.1	1
Turbidity	EPA	180.1	
Arsenic	SM	3114 B	1
Cadmium	EPA	213.2	
Cadmium	EPA	7131	
Calcium	EPA	215.1	
Calcium	EPA	7140	
Chromium	EPA	218.2	
Chromium	EPA	7191	

Washington State Department of Ecology

Laboratory Accreditation Unit

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Scope of Accreditation Report for Bureau of Reclamation - PN Regional Lab

Scope Expires: 9/14/2002

Date Printed: 9/11/2002

Parameter Name	Reference	Method Number	Notes
Copper	EPA	220.2	
Copper	EPA	7211	
Iron	EPA	236.1	
Iron	EPA	7380	
Lead	EPA	239.2	
Lead	EPA	6020	
Magnesium	EPA	7450	
Manganese	EPA	243.1	
Manganese	EPA	7460	
Mercury	EPA	245.1	
Mercury	EPA	7470	
Potassium	EPA	258.1	
Potassium	EPA	7610	
Selenium	SM	3114 B	1
Sodium	EPA	273.1	
Sodium	EPA	7770	
Zinc	EPA	289.1	
Zinc	EPA	7950	
E. coli	SM	9213 D	1
Fecal Coliforms	SM	9222 D	
Total Coliforms	SM	9222 B	1

Accredited Parameter Note Detail

(1) Interim pending on-site evaluation of capability (WAC 173-50-100).

Authentication Signature

<u>Perry Brake</u> -- Unit Supervisor, Washington State Department of Ecology -- Lab Accreditation Unit

Washington State Department of Ecology	Laboratory Accreditation Unit
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Date Printed: 9/11/2002 Scope of Accreditation Report for Bureau of Reclamation - PN Regional Lab

Scope Expires: 9/14/2002

Appendix D: Protocol for Measurement of Water Temperature Using a Thermometer

A red liquid thermometer will be used to assess water temperature during site visits. Certain thermometers will be reserved specifically for the measurement of water temperature, and these thermometers will be clearly marked to differentiate them from the thermometers used for air temperature.

Generally, the Ecology protocol for measurement of water temperature (Ecology, 1993) will be followed, with the these modifications:

- 1. At least one extra thermometer will be available at all times in the field, in the event of breakage or leaving a thermometer on-site.
- 2. Calibration of all thermometers will be checked against a NIST thermometer to assess their relationship to a true value. This will be a two-point calibration check, with one point near freezing and the second point at around 20° C. The calibration checks will occur, at a minimum, three times each year: at the beginning of each irrigation season, once during the irrigation season, and again at the end of the irrigation season.
- 3. The NIST thermometer will be sent back to the manufacturer for an annual calibration check.

Appendix F: Protocol for Measurement of Air Temperature Using Thermometer

A red liquid thermometer will be used to assess air temperature. Certain thermometers will be reserved specifically for the measurement of air temperature and will be clearly marked to differentiate them from the thermometers used for water temperature.

Measurement of air temperature will follow the Ecology protocol for measurement of water temperature (Ecology, 1993), with the following modifications:

- 1. At least one extra thermometer will be available at all times in the field, in the event of breakage or leaving a thermometer on-site.
- 2. The thermometer will be placed in the shade, for 15 minutes or until it equilibrates.
- 3. The thermometer will be hung from a staff or from secure natural vegetation, making sure that the bulb is not in contact with any other object.
- 4. The thermometer will be placed within 10 feet of the water sample collection site and between 1 and 3 feet from the ground.
- 5. Calibration of all thermometers will be checked against a NIST thermometer to assess their relationship to a true value. This will be a two point calibration check, with one point near freezing and the second point at around 20° C. The calibration checks will occur, at a minimum, three times each year: at the beginning of each irrigation season, once during the irrigation season, and again at the end of the irrigation season.
- 6. The NIST thermometer will be sent back to the manufacturer for an annual calibration check.

Appendix G: Hach 2100 P Turbidimeter Protocol

Introduction

The terms "instruction manual" or "instructions" in this protocol refer to the instruction manual that accompanies the 2100P turbidimeter. The instruction manual is the ultimate reference on using the 2100P. Rather than replace or supersede the instruction manual, this protocol intends to 1) reiterate and emphasize certain parts of the instructions, and 2) coordinate efforts in using and calibrating the 2100Ps. Any operator of the 2100P turbidimeter should thoroughly read the entire instruction manual before beginning operation.

Principle of Operation

The Hach 2100P portable turbidimeter operates on the nephelometric principle of turbidity measurement. Further, this turbidimeter has a unique optical design that incorporates signal ratioing. Light is focused into a narrow beam and passed through the sample. The 90° scatter detector receives light scattered by particles in the sample. The transmitted light detector receives light that passes through the sample. The signal output of the 2100P is a ratio (based on an algorithm) of the two detectors. By measuring both transmitted light and 90° scattered light, the 2100P compensates for background color, light fluctuations or dust and haze on the optics; these techniques increase measurement accuracy and provide long-term calibration stability.

Turbidity Measurement

Measurements may be made in manual or automatic range selection mode. <u>Using automatic range selection is recommended.</u>

Measurements may also be made with the signal average mode "on" or "off." Signal averaging uses more power and should be used only when the sample causes an unstable reading. See the instruction manual for further discussion of signal averaging.

Accurate turbidity measurement depends on good measurement technique by the analyst, such as using clean sample cells in good condition and removing air bubbles (degassing). See below for a discussion of these methods, and refer to the instruction manual for more detail regarding these measurement techniques.

Turbidity Measurement Procedure

- 1. Collect a representative sample in a clean container. Refer to the instruction manual, and the discussion below, for more information about collecting a representative sample.
- 2. Fill a sample cell to the line (about 15 mL), taking care to handle the sample cell by **the top**. Cap the cell.
- 3. Wipe the cell with a soft, lint-free cloth to remove water spots and fingerprints.

- 4. Apply a thin film of silicone oil. Wipe with a soft cloth to obtain an even film over the entire surface.
- 5. Press: I/O. The instrument will turn on. Place the instrument on a flat, sturdy surface. Do not hold the instrument while making measurements. *Note:* The instrument automatically shuts off after 5.5 minutes if no keystrokes occur. To resume operation, press I/O.
- 6. Insert the sample cell in the instrument cell compartment so the diamond or orientation mark aligns with the raised orientation mark in front of the cell compartment.
- 7. Select manual or automatic range selection by pressing the **RANGE** key. The display will show **AUTO RNG** when the instrument is in automatic range selection.
- 8. If the sample causes a "noisy" signal (display changes constantly), select signal averaging mode by pressing the **SIGNAL AVERAGE** key. The display will show **SIG AVG** when the instrument is using signal averaging. *Note:* The instrument defaults to the last operating mode selected. If automatic range mode and signal averaging were used on the previous measurements, these options will automatically be selected for subsequent samples.
- 9. Press: **READ**. The display will show ---- NTU, then the turbidity in NTU. When using automatic range selection mode, the final value is displayed after about 13 seconds. Record the turbidity after the lamp symbol turns off.

Measurement Notes

Always cap the sample cell to prevent spillage of sample into the instrument.

When taking a reading, place the instrument on a level, stationary surface. It should not be held in the hand during measurement.

Always close the sample compartment lid during measurement and storage.

Always use clean sample cells in good condition. Dirty, scratched, or damaged cells can cause inaccurate readings.

Do not leave a sample cell in the cell compartment for extended periods of time. This may compress the spring in the cell holder.

Remove sample cell and batteries from instrument if the instrument is stored for extended time period (more than a month).

Avoid operating in **direct** sunlight.

Make certain cold samples do not "fog" the sample cell.

Avoid settling of sample prior to measurement.

Keep sample compartment lid closed to prevent dust and dirt from entering.

Measurement Techniques

Proper measurement techniques are important in minimizing the effects of instrument variation, stray light and air bubbles. Regardless of the instrument used, measurements are more accurate, precise and repeatable if the analyst pays close attention to proper measurement techniques.

Measure samples immediately to prevent temperature changes and settling. Avoid sample dilution when possible.

Note: "High quality water" refers to distilled, demineralized or deionized water (turbidity < 0.5 NTU).

Cleaning Sample Cells

Cells must be extremely clean and free from significant scratches. Clean the inside and outside of the cells by washing with laboratory detergent. Follow with multiple rinses of high quality water. Allow cells to air dry. Handle cells only by the top to minimize dirt, scratches and fingerprints in the light path.

Orienting and Matching Sample Cells

Precise measurements for very low turbidity samples require using a single cell for all measurements or optically matching the cells. Yakima Valley irrigation water and return flows generally have turbidity levels that would not be considered "very low" -- therefore, when turbidimeters are used for evaluation of these waters, orienting single sample cells and matching multiple sample cells is not necessary.

However, procedures for orienting single sample cells and matching multiple sample cells MUST be followed prior to calibrating the turbidimeter. Also, if these turbidimeters are used for very low turbidity waters, these procedures must be used as well.

Orienting a Single Cell

When using a single cell, make an index or orientation mark as follows:

- 1. Fill the clean sample to the line with high quality water. Cap and wipe with the lint-free cloth. Apply silicone oil.
- 2. Press **I/O** to turn on the instrument.
- 3. Insert the sample cell into the sample compartment. Close the cover.
- 4. Press: **READ.** Record the cell's position in the cell compartment and the displayed reading.
- 5. Remove the cell, rotate it slightly and reinsert it into the cell compartment. Close the cover, then press **READ**. Record the cell's position and the displayed reading.
- 6. Repeat step 5 until the lowest reading is displayed. Place an orientation mark on the cell's marking band near the top of the cell so the cell can be consistently inserted in the position that yields the lowest reading. When using the cell, always place it in the instrument so the orientation mark aligns with the raised mark on the instrument.

Matching Multiple Sample Cells

Precise measurements of very low turbidity samples require the cells be optically matched or a single cell be used for all measurements. If more than one cell is used, follow this procedure to match (index) the cells:

- 1. Clean and oil the sample cells as instructed previously.
- 2. Fill the clean sample cells to the line with the same sample.
- 3. Press: **I/O** to turn the instrument on.
- 4. Insert the **first** sample cell into the sample compartment and close the cover.
- 5. Press: **READ**. Record the cell's position in the cell compartment and the displayed reading. Place an orientation mark on the cell's marking band. *Note:* This procedure may be easier if the user holds the **READ** key through the whole process. This allows the lamp to remain on and make continuous readings.
- 6. Insert the **second** sample cell into the cell compartment and close the cover.
- 7. Press: **READ**. Record the cell's position in the cell compartment and the displayed reading.
- 8. Remove the cell, rotate it slightly and reinsert into the cell compartment. Close the cover, then press **READ** again. Record the cell's position and the displayed reading.
- 9. Repeat step 8 until the value displayed for the second cell is within 0.01 NTU (or 1%) of the value obtained from the first cell. Place an orientation mark on the second cell's marking band so it is consistently inserted in this position. *Manufacturer's Note: Due to variability in glass, it may not be possible to match all cells.*
- 10. Repeat step 6 through step 9 if matching other sample cells.

Applying Silicone Oil

Applying a thin coat of silicone oil will mask minor imperfections and scratches which may contribute to turbidity or stray light. Use only the silicone oil provided in the turbidimeter kit. Apply the oil uniformly by wiping with a soft, lint-free cloth. **Avoid application of excess oil.** Applying excess oil may retain dirt and contaminate the instrument's cell compartment.

- 1. Thoroughly clean the sample cell.
- 2. Apply a small bead of silicone oil from the top to the bottom of the cell -- just enough to coat the cell with a thin layer of oil.
- 3. Using a soft, lint-free cloth, spread the oil uniformly, and then wipe off the excess so that only a thin coat of oil is left. The cell should appear nearly dry with little or no visible oil.

Note: After a few applications of oil, the oiling cloth (velvet) will contain enough residual oil so that simply wiping the cell with the oiled cloth will suffice. Periodically repeat above steps to replenish the oil in the cloth.

Removing Bubbles (Degassing)

Before measurement, removing air and other trapped gasses from the sample is strongly recommended, even if bubbles are not visible.

Removing air bubbles by letting the sample stand for a period of time is not recommended. Particulates that cause turbidity may settle and the sample temperature may change. Both conditions may alter sample turbidity, resulting in measurements not representative of the original turbidity.

Application of Vacuum

The vacuum lowers the atmospheric pressure, allowing trapped bubbles to escape into the air above the sample. Vacuum works well with non-viscous samples (such as water) that don't contain volatile components. Applying vacuum to viscous, volatile-containing samples (paint resins) may cause the volatile components to come out of solution and aggravate the bubble problem.

To apply a vacuum, use a sample degassing kit as follows:

- 1. Fill a sample cell to the mark with sample. Insert a #2 single-hole rubber stopper and syringe into the cell.
- 2. **Slowly** apply the vacuum by carefully pulling the plunger upward, then holding it. Apply vacuum until visible gas bubbles disappear. **Slowly** release the vacuum. Remove the vacuum apparatus and cap the cell.

Other Degassing Methods

Other degassing methods that are commonly used include:

- 1. Adding a surfactant
- 2. Using an ultrasonic bath
- 3. Heating the sample

Consult the instruction manual regarding other degassing methods if the need arises.

Measuring Overrange Samples

The measurement range of the Hach 2100P turbidimeter is 0 to 1000 NTU, with resolution to 0.01 NTU. In this case, an "overrange" sample would be over 1000 NTU (obviously very turbid), which might cause a turbidimeter to "go blind" by causing negative interference and incorrect readings. While the 2100P turbidimeter minimizes this effect with its multidetector rationing feature, the operator should be aware that "going blind" can occur. Refer to the instruction manual for further discussion of this effect.

Condensation (Fogging)

Condensation affects turbidity measurement. If condensation occurs on the outside of the sample, thoroughly wipe the moisture off the sample cell before measurement.

If fogging recurs after wiping the sample, let the sample warm slightly by standing at room temperature or immersing it in a warm bath for a short period. However, allowing samples to warm can alter sample turbidity, so avoid warming samples before measurement when possible. After warming, mix the sample thoroughly before measurement. Also, be sure to degas the sample after mixing, as shaking the sample may introduce air bubbles into the sample.

Calibration

Turbidimeters must be properly calibrated with a primary standard such as formazin. Bottles of pre-mixed StablCal formazin standards are found in the kit accompanying each turbidimeter; these standards are in concentrations of <0.1, 20, 100 and 800 NTU. The StablCal standards should be used to calibrate the turbidimeter using the calibration procedure found in Section 3.6.7 of the instruction manual. Ecology has also purchased two sets of sealed StablCal ampules, also in concentrations of <0.1, 20, 100, 800 NTU. Because the ampules are sealed, the concentrations will be more consistent than the StablCal bottles, and no pouring or measuring is necessary prior to calibration. The ampules will reside in Ecology's Yakima office, and can be used for calibration as needed.

As noted previously, procedures for orienting single sample cells and matching multiple sample cells MUST be followed prior to calibrating the turbidimeter.

Frequency of Calibration

For the purposes of the Yakima SEI project, calibration should be performed at least quarterly (every three months). If necessary, calibrate more frequently. The frequency of calibration depends on environmental conditions (humidity, temperature) and use.

Calibration Log

Operators of the 2100P turbidimeters supplied by the Yakima SEI project should keep a calibration log. The calibration log must have, at a minimum, a column for date of last calibration and a column for notes.

Preparing StablCal Stabilized Formazin Standards

This section explains how to use the bulk pre-mixed formazin standards. As noted above, pre-mixed, sealed formazin ampules are also available for calibration -- disregard this instruction if using the ampules.

When using bulk standards that have been sitting undisturbed for longer than a month, start at step 1. If the standards are used on at least a weekly interval, start at step 3.

<u>Important Note</u>: These instructions do not apply to <0.1 NTU StablCal Standards; <0.1 NTU StablCal Standards should not be shaken or inverted.

1. Shake the standard vigorously for 2-3 minutes to resuspend any particles.

- 2. Allow the standard to stand undisturbed for 5 minutes.
- 3. Gently invert the bottle of StablCal 5 to 7 times.
- 4. Prepare the sample cell for measurement using traditional preparation techniques (oiling the sample cell and marking the cell to maintain the same orientation in the sample cell compartment) to eliminate any optical variations in the sample cell.
- 5. Rinse the sample cell at least one time with the standard and discard the rinse.
- 6. Immediately fill the sample cell with the standard. Cap the sample cell and let it stand for one minute. The standard is now ready for use in the calibration process.

Calibration Procedure

For best accuracy use the same sample cell or four matched sample cells for all measurements during calibration. Instructions for orienting and matching cells are found in the previous section of this protocol. Always insert the cell so the orientation mark placed on the cell during the matching procedure is correctly aligned.

- 1. Rinse a clean sample cell with high quality water several times. Then fill the cell to the line (about 15 mL) with the StablCal <0.1 NTU standard. You can also use the <0.1 NTU StablCal ampule.
- 2. Insert the sample cell in the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment. Close the lit. Press I/O.
- 3. Press: CAL

The CAL and S0 icons will be displayed (the 0 will flash). The 4-digit display will show the value of the S0 standard for the previous calibration. If the blank value was forced to 0.0, the display will be blank. Press \rightarrow to get a numerical display.

4. Press: **READ**

The instrument will count from 60 to 0, (67 to 0 is signal average is on), read the blank and use it to calculate a correction factor for the 20 NTU standard measurement. The display will automatically increment to the next standard. Remove the sample cell from the cell compartment.

Note: The turbidity of the high quality water can be "forced" to zero by pressing \rightarrow rather than reading the high quality water. The display will show **S0** NTU and the \uparrow key must be pressed to continue with the next standard.

- 5. The display will show the **S1** (with the 1 flashing) and **20 NTU** or the value of the S1 standard for the previous calibration.
- 6. If the value is incorrect, edit the value by pressing the \rightarrow key until the number that needs editing flashes. Use the \uparrow key to scroll to the correct number.
- 7. Fill a clean sample cell to the line with the 20 NTU StablCal standard, or use the 20 NTU StablCal ampule.

8. Insert the sample cell or ampule into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid.

Press: **READ**

The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the turbidity and store the value. The display will automatically increment to the next standard. Remove the sample cell or ampule from the cell compartment.

- 9. The display will show the **S2** (with the 2 flashing) and **100 NTU** or the value for the S2 standard for the previous calibration.
- 10. Repeat step 6, above.
- 11. Fill a clean sample cell to the line with the 100 NTU StablCal standard, or use the 100 NTU StablCal ampule.
- 12. Repeat step 8, above.
- 13. The display will show the S3 (with the 3 flashing) and 800 NTU or the value for the S3 standard for the previous calibration.
- 14. Repeat step 6, above.
- 15. Fill a clean sample cell to the line with the 800 NTU StablCal standard, or use the 800 NTU StablCal ampule.
- 16. Repeat step 8, above. The display will increment back to the S0 display.
- 17. Press: **CAL** to accept calibration. The instrument will return to measurement mode automatically.

Note: Pressing **CAL** completes the calculation of the calibration coefficients. If calibration errors occurred during calibration, error messages will appear after **CAL** is pressed. If **E1** or **E2** appear, check the standard preparation and review calibration; repeat the calibration if necessary. If **CAL?** appears, an error may have occurred during calibration. If **CAL?** is flashing, the instrument is using the default calibration.

Gelex Standards

Use secondary standards (i.e., the Gelex standards) to periodically check calibration -- these standards must not be used for calibration, however. Please note that Gelex standards must be assigned values after each formazin calibration and before use as secondary standards. Gelex standards must be recalibrated each time the instrument is calibrated with formazin. Directions for assigning values to the Gelex standards can be found in the instruction manual. Gelex standards can be used as needed to check instrument calibration; when the turbidity reading of the Gelex standard is not within 5% of the previously established value, the instrument should be recalibrated with formazin primary standard.

Representative Sampling

A representative sample accurately reflects the true condition of the water source from which the sample was taken. To ensure a representative sample, gently, but thoroughly, mix every sample before portions are taken. Do not allow the sample to settle.

When sampling from a stream, irrigation ditch, or other waterbody, collect at least one liter and thoroughly mix before measurement. If the water source is not uniform, it may be necessary to

sample several locations at varying depths and combine the samples into a single, well-mixed composite sample before measurement.

Avoid sample dilution when possible. Particles suspended in the original sample may dissolve or otherwise change characteristics when the sample temperature changes or when the sample is diluted, resulting in a non-representative sample measurement.

Maintenance

Regular maintenance is critical to proper operation of the Hach 2100P portable turbidimeter. See the instruction manual for specific instructions on regular maintenance procedures.

Keep the turbidimeter and accessories as clean as possible and store the instrument in the carrying case when not in use. Avoid prolonged exposure to sunlight and ultraviolet light. Wipe up spills promptly.

Appendix H: Glossary of Terms

<u>Accuracy</u>: Accuracy refers to the difference between the measured result and the true value of the parameter being determined. A measure of confidence that the data collected in the field and in the laboratory reflect the true value of a given parameter.

<u>Bias</u>: A measure of the difference between the result for a parameter and the true value due to *systematic* errors. Bias is commonly caused by faulty sample collection methods, but may be introduced in the laboratory as well.

<u>Comparability</u>: Comparability refers to the ability to compare the data from a project to other data, which may be data collected by other groups or data collected by the project in other years. If comparability is required, the different groups should use equivalent sampling procedures and analytical methods. Sometimes interlaboratory comparison studies can be used to establish comparability of analytical data.

<u>Completeness</u>: Data completeness refers to the amount of data that is successfully collected and validated with respect to the amount intended in the project design. A certain percentage of the intended data must be successfully determined for valid conclusions to be reached. Completeness is usually expressed in percent.

<u>Detection Limit</u>: The detection limit is the lowest concentration that the laboratory is able to detect using the method; it should be lower than the reporting limit.

Grab Sample: A single sample of water taken without regard to time or flow.

<u>Integrated Sample</u>: A sample taken with an integrated sampler, which combines and represents the area of a stream section.

<u>Precision</u>: A measure of the scatter in the data due to random error. Precision refers to the relative agreement between duplicate determinations and serves as a record of repeatability of an analytical procedure. Often stated in term of the relative percent difference (RPD).

<u>Quality Assurance/Quality Control</u>: A system of procedures, checks, audits, and corrective actions to ensure that all technical, operational, monitoring, and reporting activities are of the highest achievable quality.

Relative Percent Difference (RPD): A method of comparing the precision of replicate samples. RPD can be calculated by dividing the absolute value of the difference between the replicates by the mean of the replicates.

<u>Reporting Limit</u>: The lowest concentration that a laboratory is confident in reporting as a true value. (see also "detection limit")

<u>Representativeness</u>: Representativeness is a measure of the extent to which the measurements obtained actually depict the true environmental condition being evaluated.

<u>Sampling Event</u>: A period when all samples are collected and field analyses completed at a single location at one time

Sampling Excursion: A series of sampling events that will normally take place in a single day.

Appendix I: Site Descriptions

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Mainstem Teanaway at Lambert Bridge

Logger Serial #: 566364 (launched June 26th)

Location: T19N R16E S3-4 **GPS:** 47° 10′ 30.51″ N 120° 50′ 09.84″ W

Elevation: ~1891 ft.

Driving Directions: Site location is on north side of bridge at the junction of Lambert and Seaton roads. *From Cle Elum*, drive toward the Teanaway on Hwy 970; take right onto Lambert Rd just after Hwy 10. *From Ellensburg*, drive toward Cle Elum on Hwy 10, take right onto Hwy 970, and take right onto Lambert Rd. *From Teanaway*, drive toward Cle Elum on Hwy 970, take left onto Seaton Rd. Park at bridge. Hobo is on north side of the bridge in brush on west bank.

Pictures:





Mainstem Teanaway at Red Bridge

Logger Serial #: 566369 (launched June 26th)

Location: T20N R16E S25 **GPS:** 47° 12' 05.27" N 120° 46' 53.05" W

Elevation: ~2024 ft.

Driving Directions: Site location is on north side of bridge Red Bridge Rd. *From Cle Elum*, drive toward the Teanaway on Hwy 970, take left onto Teanaway Rd, go ¼ mile and take left onto Red Bridge Rd. *From Ellensburg*, drive toward Cle Elum on Hwy 10, take right onto Hwy 970, and take left onto the Teanaway Rd. Park at bridge. Hobo is on north side of the bridge in brush on east bank.

Pictures:







Mainstem Teanaway at Burke Property

Logger Serial #: 566375

Location: T20N R16E S14 **GPS:** 47° 13′ 52.92″ N 120° 48′ 51.15″ W

Elevation: ~2139 ft.

Driving Directions: Drive up the Teanaway Rd and go to Violet Burke's property. Must receive permission to access property. Hobo is attached to a rock bar on east bank. Another Hobo for measuring ambient temperature is installed in the next rock bar just downstream from first Hobo on east bank.







North Fork Teanaway at Mouth

Logger Serial #: 566372

Location: T20N R16E S6 GPS: 47° 15' 26.60" N 120° 52' 48.29" W

Elevation: ~2300 ft.

Driving Directions: Drive up Teanaway Rd until you cross the North Fork bridge. Continue a short distance. Park on shoulder at the West Fork junction. Walk along west bank upstream to aqua colored bedrock. Hobo is attached to woody debris on west bank in pool.





Middle Fork Teanaway at Mouth - Shared Site with USFS

Logger Serial #: 566368

Location: T20N R16E S06 **GPS:** 47° 15′ 31.90″ N 120° 53′ 51.42″ W

Elevation: ~2308 ft.

Driving Directions: Take Teanaway Road to the West Fork Teanaway Road. Park on east side of bridge. During high flow, walk into riparian brush on east bank just upstream from bridge. Hobo is attached to brush on east bank in pool. Easy to access site during low flow by walking through Middle Fork from the west shore.







West Fork Teanaway at Mouth

Logger Serial #: 566365

Location: T20N R16E S06 **GPS:** 47° 15' 25.08" N 120° 53' 56.55" W

Elevation: ~2308 ft.

Driving Directions: Take Teanaway Road to the West Fork Teanaway Road. Cross bridge over the Middle Fork Teanaway River. Park at west end of bridge. Optional to park here for both Middle Fork and West Fork site access. Walk southwest along path to the West Fork. Site is just downstream from the rock face. Hobo attached to woody debris on south bank of West Fork.







North Fork Teanaway at Dickey Creek

Logger Serial #: 566366

Location: T21N R16E S29 **GPS:** 47° 17′ 17.11″ N 120° 51′ 33.15″ W

Elevation: ~2462 ft.

Driving Directions: Drive up Teanaway Rd until you reach the <u>second</u> North Fork bridge. Park on the south side of bridge. Walk along the south bank downstream to woody debris (~ 500+ ft). Hobo is attached to woody debris on south bank in pool just upstream from Dickey Creek mouth.





North Fork Teanaway at Middle Creek

Logger Serial #: 566370

Location: T21N R16E S20 **GPS:** 47° 17′ 49.16″ N 120° 51′ 25.39″ W

Elevation: ~2498 ft.

Driving Directions: Drive up Teanaway Rd until you reach the US Timberland Middle Creek gate. Park on west side of Teanaway Rd just across from the Middle Creek gate. Walk through barbed-wire gate and follow fence line towards river along cattle trail. Hobo is attached to woody debris on east bank in pool just upstream from Middle Creek mouth (between Indian Creek and Middle Creek).







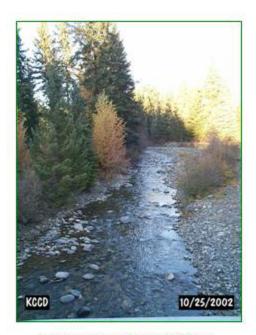


North Fork at USFS Road 9701

Latitude 47-20-00.62 Longitude 120-51-20.91

Parameters:

- Total Suspended Solids
- Turbidity
- Temperature
- Stream Discharge



Upstream side of bridge



Collecting Velocity measurements for stream discharge calculations. Samples are usually collected at this site. At extreme high flows, samples will be collected and flows measured from the bridge.

The staff gage reading is taken from a known point on the bridge using a fiberglass surveyor's rod.



Downstream side of bridge

Stafford Creek at USFS Road 9737

Latitude Longitude



Sampling site at Stafford Creek bridge at USFS Road 9737



Upstream view below bridge

Note: Stafford Creek and Beverly Creek are additional sampling sites to be sampled when accessible after storm events. Stafford Creek bridge is 1 mile up and Beverly Creek bridge is 4 miles up USFS Road 9737. No GPS data are available for either site and no pictures are available of Beverly Creek at this time.

- Total Suspended Solids
- Turbidity
- Temperature
- Stream Discharge



Downstream side of bridge



Downstream view above bridge

Jack Creek at NF Teanaway Road

Latitude 47-19-27.53 Longitude 120-51-09.14

- Total Suspended Solids
- Turbidity
- Temperature
- Stream Discharge



Downstream side of culvert



Upstream side of culvert



Looking Downstream from the culvert

Indian Creek at NF Teanaway Road

Latitude 47-19-27.53 Longitude 120-51-09.14





Upstream side of culvert (same view- with and without snow)
Samples and measurements are generally collected 20 to 40' upstream of the culvert.



Downstream side of culvert

- Total Suspended Solids
- Turbidity
- Temperature
- Stream Discharge

Middle Creek at NF Teanaway Road

Latitude 47-17-43.05 Longitude 120-51-18.53





Downstream side of culvert

Downstream side of culvert

- Total Suspended Solids
- Turbidity
- . Temperature
- Stream Discharge



Upstream side of culvert. Samples and measurements are generally collected just upstream of the culvert.

North Fork Teanaway River at NF Teanaway Road (above Dickey Creek)

Latitude 47-17-22.36 Longitude 120-51-34.76



Looking downstream from the bridge



Looking upstream from the bridge



Collecting Velocity measurements for stream discharge calculations usually occurs 50-100' upstream of the bridge. At extreme high flows, samples will be collected and flows measured from the bridge.



Downstream view above bridge. Staff gage readings taken from known point on bridge.

- Total Suspended Solids
- Turbidity
- Temperature

Lick Creek at NF Teanaway Road

Latitude

Longitude

Parameters:

- Total Suspended Solids
- Turbidity
- Temperature
- Stream Discharge



Downstream side of double culvert



Upstream side of double culvert

Note: Lick Creek is ephemeral. No water observed during Summer and Fall of 2002. First sampling conducted on December 16, 2002. No GPS data is available at this time.



Upstream side of double culvert with water

North Fork Teanaway River at Teanaway Road

Latitude 47-15-16.69 Longitude 120-52-42.75





Upstream side of bridge

Parameters:

- Total Suspended Solids
- Turbidity
- . Temperature
- Stream Discharge

Series of pictures from below bridge. Sample location is usually directly downstream of the bridge. At extreme high flows, samples will be collected and flows measured from the bridge.

Staff gage readings are taken from a known point on downstream side of the bridge.



Downstream side of bridge

Middle Fork Teanway River at West Fork Road

Latitude 47-15-30.82 Longitude 120-53-52.11



Taking staff gage reading using a fiberglass surveying rod and a known point on the bridge.

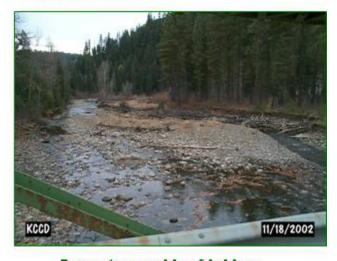


Upstream side of bridge

Parameters:

- Total Suspended Solids
- Turbidity
- Temperature
- Stream Discharge

Sampling usually occurs 100-200 feet upstream of the bridge. At extreme high flows, samples will be collected and flows measured from the bridge. Staff gage readings taken on upstream side of the bridge.



Downstream side of bridge

West Fork Teanway River Near End of County Road

Latitude 47-15-30.79 Longitude 120-54-21.64



E → W

Pictures taken in a series from the parking lot at end of County Road. Sampling conducted downstream of the bridge. At extreme high flows, samples will be collected and flows measured from the bridge. Staff gage reading taken at bridge.

- Total Suspended Solids
- . Turbidity
- Temperature
- Stream Discharge

Teanaway River at Red Bridge Road

Latitude 47-12-04.91 Longitude 120-46-54.17



Parameters:

- **Total Suspended** Solids
- Turbidity
- **Temperature**
- **Stream Discharge**

Looking downstream from Red Bridge Road



Looking upstream from bridge. Samples usually collected where staff are in this picture. Staff gage readings are taken from a known point on upstream side of bridge. At extreme high flows, samples will be collected and flows measured from the bridge.

Teanaway River at Lambert Road

Latitude 47-10-29.55 Longitude 120-50-11.28



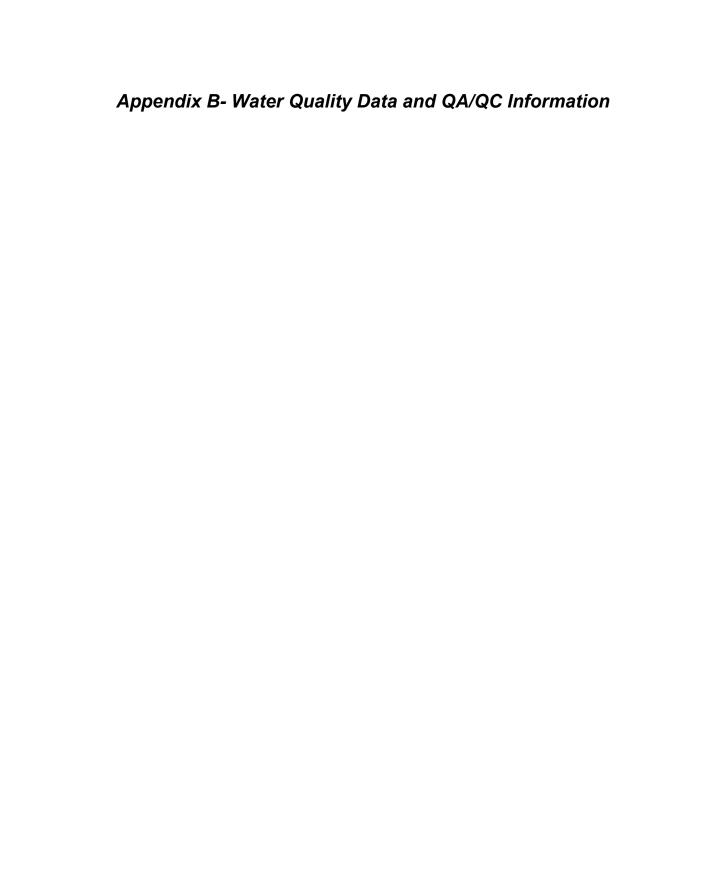
Parameters:

- Total Suspended Solids
- Turbidity
- . Temperature
- Stream Discharge

Upstream side of bridge. Samples are sometimes collected in the main channel on the left side of this picture. That occurs only when flows are so low they exist only in that main channel.



Looking downstream from the bridge. When flows are higher, samples and measurements are collected at the site where staff can be seen in this picture. Staff gage readings are collected at a known point on the downstream side of the bridge with a fiberglass surveying rod. At extreme high flows, samples will be collected and flows measured from the bridge.



All water quality data collected for the Reduce Teanaway Temperatures Project may be accessed digitally on the attached disc or requested in hard copy from the KCCD office.

Quality Control and Quality Assurance Calculations and Data

The following pages contain the calculations of the relative percent differences (RPD) for various parameters. See Table 4 and Table 5 (taken directly from the QAPP) for required RPD's and RPD's calculated for KCCD and KRD/KCWP data in previous sampling seasons.

Table 1. Summary of field and laboratory methods with precision limits

Parameter	Method and Reference ¹	Precision Limit
Field Measureme		
Velocity	Ecology, 1993 – Marsh-McBirney flow meter	less than 20% RPD ²
	Ecology, 1993 - Red liquid thermometer	± 0.1° C
Water Temperature	Appendix C - HOBO temperature data logger	± 0.2° C
Laboratory Meas	surements	
Turbidity	EPA 180.1	20% RPD
Total Suspended Solids	EPA 160.2	20% RPD

Table 2: Estimates of laboratory and field precision. Mean relative percent difference (RPD) of laboratory duplicates of samples analyzed by the USBR Boise Laboratory in 1999, and of field replicates collected by the KRD in 1999.

{PRIVATE}Para meter	KRD 1999 Laboratory Duplicates (Mean % RPD)	Number of Records	2000 KCCD Field Replicates (Mean % RPD)	Number of Records
Total Suspended Solids	11.06	204	3.82	13
Turbidity	1.06	202	0.0	13

In addition to the calculated RPDs, the following pages also contain the data analysis for the blank samples shipped to the USBOR lab for analyses.

EPA: U.S. Environmental Protection Agency, 1983

¹ Methods and References:

² RPD = relative percent difference

Relative Percent Difference Calculations for Field Turbidity Data from the Hach 2100 P

Site Description	BOR Site Code	Date	Time	2100 P Field Turbidity	Relative Percent Difference
North Fork @ USFS Rd 9701	YAV 220		12:30 PM	0.14	3.4%
North Fork @ USFS Rd. 9701 (replicate)	YAV 220	22-Sep-03		0.15	J. 4 /0
Middle Fork near Mouth	YAV 234	6-Oct-03	10:05 AM	0.10	20.0%
Middle Fork near Mouth (replicate)	YAV 234	6-Oct-03	10:15 AM	0.15	_0.070
Middle Fork near Mouth	YAV 234	5-Nov-02	11:03 AM	0.11	29.0%
Middle Fork near Mouth (replicate)	YAV 234	5-Nov-02	11:03 AM	0.2	_0.070
North Fork @ USFS 9701 (replicate)	YAV 220	14-Jul-03	9:25 AM	0.17	19.0%
North Fork @ USFS Rd 9701	YAV 220	14-Jul-03	9:00 AM	0.25	101070
Middle Fork near Mouth	YAV 234	11-Aug-03		0.29	13.7%
Middle Fork near Mouth (replicate)	YAV 234	11-Aug-03		0.22	
North Fork @ Dickey Ck	YAV 228	4-Nov-02	12:53 PM	0.27	3.8%
North Fork @ Dickey Ck (replicate)	YAV 228	4-Nov-02	12:53 PM	0.25	
North Fork @ USFS Rd 9701	YAV 220	18-Nov-02	12:35 PM	0.43	56.4%
North Fork @ USFS Rd 9701 (replicate)	YAV 220	18-Nov-02		0.12	
North Fork near Mouth	YAV 232	30-Dec-02	12:05 PM	0.95	26.7%
North Fork near Mouth (replicate)	YAV 232	30-Dec-02		0.55	
North Fork @ Dickey Ck	YAV 228	13-Jan-03		0.3	15.5%
North Fork @ Dickey Ck (replicate)	YAV 228	13-Jan-03		0.41	101070
Middle Fork near Mouth	YAV 234			0.61	15.9%
Middle Fork near Mouth (replicate)	YAV 234	10-Feb-03		0.84	101070
West Fork near Mouth	YAV 236			0.69	2.1%
West Fork near Mouth (Replicate)	YAV 236	19-May-03		0.72	,0
North Fork @ Dickey Ck	YAV 228	16-Jun-03		0.54	17.4%
North Fork @ Dickey Ck (replicate)	YAV 228	16-Jun-03		0.38	111170
Mainstem @ Lambert Rd	YAV 240	28-Jul-03	9:25 AM	0.87	19.2%
Mainstem @ Lambert Rd (replicate)	YAV 240	28-Jul-03	9:55 AM	0.59	
Mainstem @ Lambert Rd	YAV 240	8-Sep-03	12:15 PM	0.42	39.1%
Mainstem @Lambert (replicate)	YAV 240	8-Sep-03	12:25 PM	0.96	001170
Jack Ck @ NF Teanaway Rd	YAV 222		1:30 PM	0.76	10.1%
Jack Ck @NF Teanaway Rd (replicate)	YAV 222	20-Oct-03	1:40 PM	0.93	1011,0
NF Teanaway @ Dickey Ck (Replicate)	YAV 228	29-Dec-03		0.19	9.5%
North Fork @ Dickey Ck	YAV 228	29-Dec-03		0.23	0.070
West Fork near Mouth	YAV 236			1.55	33.6%
West Fork near Mouth (replicate)	YAV 236			0.77	00.070
Indian Ck @ NF Teanaway Rd	YAV 224	4-Dec-02	10:00 AM	1.14	7.7%
Indian Ck @ NF Teanaway Rd (replicate)	YAV 224	4-Dec-02	10:30 AM	1.33	111 70
Jack Ck @ NF Teanaway Rd	YAV 222			1.78	7.5%
Jack Creek @ NF Teanaway Road (Replicate)	YAV 222	21-Apr-03	12:45pm	2.07	
North Fork near Mouth	YAV 232	7-Apr-03	1:00PM	2.27	2.5%
North Fork Near Mouth (Replicate)	YAV 232	7-Apr-03	12:25PM	2.16	
Jack Ck @ NF Teanaway Rd	YAV 222	24-Mar-03	10:00 AM	3.37	1.4%
Jack Ck @ NF Teanaway Rd(Replicate)	YAV 222	24-Mar-03	10:30 AM	3.28	,
North Fork @ Dickey Ck	YAV 228	24-Feb-03		3.94	4.5%
North Fork @ Dickey Ck (replicate)	YAV 228	24-Feb-03	11:55 AM	4.31	,0
Lick Ck @ NF Teanaway Rd	YAV 230	5-May-03	11:30pm	8.69	1.2%
Lick Creek @ NF Teanaway Road (Replicate)	YAV 230	5-May-03	11:45am	8.49	,,
Lick Ck @ NF Teanaway Rd	YAV 230	10-Mar-03	1:40 PM	16.6	0.3%
Lick Ck @ NF Teanaway Rd (replicate)	YAV 230	10-Mar-03		16.5	3.370
Jack Ck @ NF Teanaway Rd	YAV 222	18-Nov-03		21	4.5%
Jack Creek @ NF Teanaway Road (Replicate)	YAV 222	18-Nov-03	11:25 AM	19.2	
Indian Ck @ NF Teanaway Rd	YAV 224	27-Jan-03	2:05 PM	38.9	14.1%
Indian Ck @ NF Teanaway Rd (replicate)	YAV 224	27-Jan-03	2:05 PM	51.7	1-1.170
	1			r of Records	26

Number of Records 26 Average 15% Number exceeding 20% 5

*All five exceedences involved values of less than 1NTU

1

Relative Percent Difference Calculations for Suspended Sediment and Turbidity Data from the USBOR Lab

					Suspended	Relative		Relative
211. 2	BOR Site			BOR Log	Sediment	Percent	Turbidity	Percent
Site Description	Code	Date	Time	Number	mg/L	Difference	NTU	Difference
North Fork @ Dickey Ck North Fork @ Dickey Ck (replicate)	YAV 228 YAV 228	4-Nov-02 4-Nov-02	12:53 PM 12:53 PM		1 <1	Incalcuable -only	< 1 < 1	Incalcuable -only
North Fork @ Dickey Ck	YAV 228	13-Jan-03			<1	one known value Incalcuable -only	<1	one known value Incalcuable -onlv
North Fork @ Dickey Ck (replicate)	YAV 228	13-Jan-03	11:20 AM		< 1	one known value	< 1	one known value
North Fork @ USFS 9701 (replicate)		14-Jul-03		03-A3002	< 1	Incalcuable -only	< 1	Incalcuable -only
North Fork @ USFS Rd 9701	YAV 220	14-Jul-03	9:00 AM	03-A2992	< 1	one known value	< 1	one known value
Mainstem @ Lambert Rd	YAV 240	28-Jul-03		03-A3805	< 1	Incalcuable -only	< 1	Incalcuable -only
Mainstem @ Lambert Rd (replicate)	YAV 240	28-Jul-03		03-A3806	< 1	one known value	1	one known value
Middle Fork near Mouth Middle Fork near Mouth (replicate)	YAV 234 YAV 234				< 1 < 1	Incalcuable -only	1	Incalcuable -only
North Fork @ USFS Rd 9701	YAV 220				<1	one known value Incalcuable -only	< 1	one known value Incalcuable -only
North Fork @ USFS Rd. 9701 (replicate)	YAV 220	22-Sep-03			< 1	one known value	<1	one known value
Middle Fork near Mouth	YAV 234		10:05 AM		< 1	Incalcuable -only	1	Incalcuable -only
Middle Fork near Mouth (replicate)	YAV 234	6-Oct-03		03-A6193	1	one known value	< 1	one known value
Jack Ck @ NF Teanaway Rd	YAV 222	20-Oct-03	1:30 PM	03-A6388	< 1	Incalcuable -only	2	Incalcuable -only
Jack Ck @NF Teanaway Rd (replicate)	YAV 222	20-Oct-03		03-A6397	1	one known value	2	one known value
NF Teanaway @ Dickey Ck (Replicate)	YAV 228			03-A7000	< 1	Incalcuable -only	< 1	Incalcuable -only
North Fork @ Dickey Ck	YAV 228	29-Dec-03		03-A6994	<1	one known value	< 1	one known value
North Fork @ USFS Rd 9701 North Fork @ USFS Rd 9701 (replicate)	YAV 220 YAV 220	18-Nov-02 18-Nov-02	12:35 PM 12:50 PM		< 1	Incalcuable -only one known value	2	Incalcuable -only one known value
North Fork @ Dickey Ck	YAV 228	16-Jun-03		03-A1920	< 1	Incalcuable -only	< 1	Incalcuable -only
North Fork @ Dickey Ck (replicate)	YAV 228	16-Jun-03	10:10 AM		2	one known value	< 1	one known value
Middle Fork near Mouth	YAV 234	30-Jun-03	9:50 AM	03-A2283	< 1	Incalcuable -only	< 1	Incalcuable -only
Middle Fork near Mouth (replicate)	YAV 234	30-Jun-03	10:00 AM	03-A2287	7	one known value	1	one known value
Mainstem @ Lambert Rd	YAV 240	8-Sep-03	12:15 PM	03-A5535	2	0%	< 1	Incalcuable -only
Mainstem @Lambert (replicate)	YAV 240	8-Sep-03	12:25 PM	03-A5536	2		< 1	one known value
Indian Ck @ NF Teanaway Rd	YAV 224	4-Dec-02	10:00 AM	02-A5532	2	0%	> 1	Incalcuable -only
Indian Ck @ NF Teanaway Rd (replicate)	YAV 224	4-Dec-02	10:30 AM	02-A5540	2		1	one known value
North Fork near Mouth	YAV 232	30-Dec-02	12:05 PM	02-A5790	2	0%	< 1	Incalcuable -only
North Fork near Mouth (replicate)	YAV 232	30-Dec-02	12:45 PM	02-A5795	2		1	one known value
North Fork near Mouth	YAV 232	7-Apr-03	1:00PM	03-A674	3	20%	2	0%
North Fork Near Mouth (Replicate)	YAV 232	7-Apr-03		03-A679	2	2070	2	3 70
Jack Ck @ NF Teanaway Rd	YAV 222	21-Apr-03		03-A910	2	20%	2	0%
Jack Creek @ NF Teanaway Road (Replicate)	YAV 222	21-Apr-03		03-A910 03-A920	3	20 /0	2	U /0
Middle Fork near Mouth			-		_	43%		
	YAV 234	10-Feb-03	11:30 AM		5	43%	<1	Incalcuable -only
Middle Fork near Mouth (replicate)	YAV 234	10-Feb-03			2	222/	< 1	one known value
West Fork near Mouth	YAV 236	19-May-03			3	20%	< 1	Incalcuable -only
West Fork near Mouth (Replicate)	YAV 236	19-May-03			2		1	one known value
North Fork @ Dickey Ck	YAV 228	24-Feb-03	12:00 PM	03-A364	4	0%	4	0%
North Fork @ Dickey Ck (replicate)	YAV 228	24-Feb-03	11:55 AM	03-A371	4		4	
Jack Ck @ NF Teanaway Rd	YAV 222	24-Mar-03	10:00 AM	03-A602	6	0%	4	0%
Jack Ck @ NF Teanaway Rd(Replicate)	YAV 222	24-Mar-03	10:30 AM	03-A613	6		4	
Lick Ck @ NF Teanaway Rd	YAV 230	5-May-03	11:30pm	03-A1074	6	0%	8	0%
Lick Creek @ NF Teanaway Road (Replicate)	YAV 230	5-May-03	_	03-A1080	6		8	
West Fork near Mouth	YAV 236	25-Aug-03			8	33%	2	0%
West Fork near Mouth (replicate)	YAV 236	25-Aug-03			4	2370	2	- 70
Lick Ck @ NF Teanaway Rd	YAV 230	10-Mar-03		03-A453	15	3%	14	0%
Lick Ck @ NF Teanaway Rd (replicate)	YAV 230	10-Mar-03		03-A453 03-A459	16	J /0	14	0 /0
, , , , ,						00/		00/
Jack Ck @ NF Teanaway Rd	YAV 222	18-Nov-03			42	9%	11	0%
Jack Creek @ NF Teanaway Road (Replicate)	YAV 222	18-Nov-03			35	401	11	461
Indian Ck @ NF Teanaway Rd	YAV 224	27-Jan-03		03-A144	94	1%	36	1%
Indian Ck @ NF Teanaway Rd (replicate)	YAV 224	27-Jan-03	2:05 PM	03-A153	93		37	
				Numbe	er of Records			9

 Number of Records
 14
 9

 Average
 11%
 0%

 Number exceeding 20%
 2
 0

	BOR Site			Ambient Air	Relative Percent	Stream	Relative Percent
Site Description	Code	Date	Time	Temperature	Difference	Temperature	Difference
North Fork @ Dickey Ck	YAV 228	4-Nov-02	12:53 PM	8.3	0%	2.5	0%
North Fork @ Dickey Ck (replicate)	YAV 228	4-Nov-02	12:53 PM	8.3		2.5	
North Fork @ USFS Rd 9701	YAV 220	18-Nov-02		7	2%	4.5	0%
North Fork @ USFS Rd 9701 (replicate)	YAV 220	18-Nov-02	12:50 PM	6.7		4.5	
Indian Ck @ NF Teanaway Rd	YAV 224	4-Dec-02	10:00 AM	0.8	0%	0.3	0%
Indian Ck @ NF Teanaway Rd (replicate)	YAV 224	4-Dec-02	10:30 AM	0.8		0.3	
North Fork near Mouth	YAV 232	30-Dec-02	12:05 PM	2.4	0%	0.4	0%
North Fork near Mouth (replicate)	YAV 232	30-Dec-02	12:45 PM	2.4		0.4	
North Fork @ Dickey Ck	YAV 228	13-Jan-03	11:10 AM	2	0%	1.8	0%
North Fork @ Dickey Ck (replicate)	YAV 228	13-Jan-03	11:20 AM	2		1.8	
Middle Fork near Mouth	YAV 234	10-Feb-03	11:30 AM	8	45%	2.5	0%
Middle Fork near Mouth (replicate)	YAV 234	10-Feb-03	11:30 AM	3		2.5	
North Fork @ Dickey Ck	YAV 228	24-Feb-03	12:00 PM	0.5	50%	1	60%
North Fork @ Dickey Ck (replicate)	YAV 228	24-Feb-03	11:55 AM	1.5		0.25	
Lick Ck @ NF Teanaway Rd	YAV 230	10-Mar-03	1:40 PM	7	3%	2.8	11%
Lick Ck @ NF Teanaway Rd (replicate)	YAV 230	10-Mar-03	1:30 PM	7.5		3.5	
Jack Ck @ NF Teanaway Rd	YAV 222	24-Mar-03	10:00 AM	3	14%	3.5	3%
Jack Ck @ NF Teanaway Rd(Replicate)	YAV 222	24-Mar-03	10:30 AM	4		3.3	
North Fork near Mouth	YAV 232	7-Apr-03	1:00PM	12	4%	7.5	6%
North Fork Near Mouth (Replicate)	YAV 232	7-Apr-03	12:25PM	11		6.7	
Jack Ck @ NF Teanaway Rd	YAV 222	21-Apr-03	12:23pm	12	4%	6	3%
Jack Creek @ NF Teanaway Road (Replicate)	YAV 222	21-Apr-03	12:45pm	11		5.7	
Lick Ck @ NF Teanaway Rd	YAV 230	5-May-03	11:30pm	13	0%	7.4	0%
Lick Creek @ NF Teanaway Road (Replicate)	YAV 230	5-May-03	11:45am	13		7.4	
West Fork near Mouth	YAV 236	19-May-03	12:15 PM	15.5	2%	9.4	6%
West Fork near Mouth (Replicate)	YAV 236	19-May-03	12:30 PM	16		8.4	
North Fork @ Dickey Ck	YAV 228	16-Jun-03	9:35 AM	18.5	0%	9	0%
North Fork @ Dickey Ck (replicate)	YAV 228	16-Jun-03	10:10 AM	18.5		9	
Mainstem @ Lambert Rd	YAV 240	28-Jul-03	9:25 AM	29.5	0%	18.1	1%
Mainstem @ Lambert Rd (replicate)	YAV 240	28-Jul-03	9:55 AM	29.5		18.5	
Middle Fork near Mouth	YAV 234	11-Aug-03	10:15 AM	19.5	0%	17.2	0%
Middle Fork near Mouth (replicate)	YAV 234	11-Aug-03	10:25 AM	19.5		17.2	
West Fork near Mouth	YAV 236	25-Aug-03	11:35 AM	26	0%	18.5	0%
West Fork near Mouth (replicate)	YAV 236	25-Aug-03	11:45 AM	26		18.5	
Mainstem @ Lambert Rd	YAV 240	8-Sep-03	12:15 PM	17.5	0%	16.5	0%
Mainstem @Lambert (replicate)	YAV 240	8-Sep-03	12:25 PM	17.5		16.5	
North Fork @ USFS Rd 9701	YAV 220	22-Sep-03		27	2%	12.2	0%
North Fork @ USFS Rd. 9701 (replicate)	YAV 220	22-Sep-03		26		12.3	
Middle Fork near Mouth	YAV 234	6-Oct-03	10:05 AM	18.5	0%	11	0%
Middle Fork near Mouth (replicate)	YAV 234	6-Oct-03	10:15 AM	18.5		11	
Jack Ck @ NF Teanaway Rd	YAV 222	20-Oct-03	1:30 PM	13	0%	10.1	0%
Jack Ck @NF Teanaway Rd (replicate)	YAV 222	20-Oct-03		13		10.1	
NF Teanaway @ Dickey Ck (Replicate)	YAV 228	29-Dec-03		-6	0%	0.25	0%
North Fork @ Dickey Ck	YAV 228	29-Dec-03		-6	- /0	0.25]
		_0 200 00		er of Records	22	J. E V	22

 Number of Records
 22
 22

 Average
 6%
 4%

 Number exceeding 20%
 2
 1

Relative Percent Difference Calculations for Discharge Measurements (Velocity Collected with Marsh McBirney Velocity Meter)

Site Description	BOR Site Code	Date	Time	Discharge (CFS)	Relative Percent Difference
West Fork near Mouth	YAV 236	25-Aug-03	11:35 AM	0.28	46%
West Fork near Mouth (replicate)	YAV 236	25-Aug-03	11:45 AM	0.74	
Jack Ck @ NF Teanaway Rd	YAV 222	20-Oct-03	1:30 PM	0.79	3%
Jack Ck @NF Teanaway Rd (replicate)	YAV 222	20-Oct-03	1:40 PM	0.84	
Middle Fork near Mouth	YAV 234	6-Oct-03	10:05 AM	0.78	20%
Middle Fork near Mouth (replicate)	YAV 234	6-Oct-03	10:15 AM	1.18	
Lick Ck @ NF Teanaway Rd	YAV 230	5-May-03	11:30pm	2.60	11%
Lick Creek @ NF Teanaway Road (Replicate)	YAV 230	5-May-03	11:45am	2.07	
Middle Fork near Mouth	YAV 234	11-Aug-03	10:15 AM	2.65	2%
Middle Fork near Mouth (replicate)	YAV 234	11-Aug-03	10:25 AM	2.55	
Jack Ck @ NF Teanaway Rd	YAV 222	18-Nov-03	11:10 AM	6.10	5%
Jack Creek @ NF Teanaway Road (Replicate)	YAV 222	18-Nov-03	11:25 AM	6.73	
Mainstem @ Lambert Rd	YAV 240	8-Sep-03	12:15 PM	8.13	3%
Mainstem @Lambert (replicate)	YAV 240	8-Sep-03	12:25 PM	7.73	
Lick Ck @ NF Teanaway Rd	YAV 230	10-Mar-03	1:40 PM	10.34	5%
Lick Ck @ NF Teanaway Rd (replicate)	YAV 230	10-Mar-03	1:30 PM	9.42	
North Fork @ USFS Rd 9701	YAV 220	22-Sep-03	12:30 PM	11.56	9%
North Fork @ USFS Rd. 9701 (replicate)	YAV 220	22-Sep-03	12:30 PM	13.71	
North Fork @ USFS Rd 9701	YAV 220	18-Nov-02	12:35 PM	15.55	18%
North Fork @ USFS Rd 9701 (replicate)	YAV 220	18-Nov-02	12:50 PM	10.72	10,70
North Fork @ Dickey Ck	YAV 228	4-Nov-02	12:53 PM	15.69	2%
North Fork @ Dickey Ck (replicate)	YAV 228	4-Nov-02	12:53 PM	16.27	-73
Jack Ck @ NF Teanaway Rd	YAV 222	21-Apr-03	12:23pm	17.60	1%
Jack Creek @ NF Teanaway Road (Replicate)	YAV 222	21-Apr-03	12:45pm	17.20	. 70
Middle Fork near Mouth	YAV 234	30-Jun-03	9:50 AM	18.32	1%
Middle Fork near Mouth (replicate)		30-Jun-03	10:00 AM	18.79	- / /
Mainstem @ Lambert Rd	YAV 240	28-Jul-03	9:25 AM	19.31	3%
Mainstem @ Lambert Rd (replicate)	YAV 240	28-Jul-03	9:55 AM	18.10	- 70
North Fork near Mouth	YAV 232	30-Dec-02	12:05 PM	24.92	2%
North Fork near Mouth (replicate)	YAV 232	30-Dec-02	12:45 PM	25.74	-/-
Jack Ck @ NF Teanaway Rd	YAV 222	24-Mar-03	10:00 AM	39.51	7%
Jack Ck @ NF Teanaway Rd(Replicate)	YAV 222	24-Mar-03	10:30 AM	34.55	. 70
North Fork @ Dickey Ck	YAV 228	13-Jan-03	11:10 AM	40.34	14%
North Fork @ Dickey Ck (replicate)	YAV 228	13-Jan-03	11:20 AM	30.36	,,
North Fork @ USFS 9701 (replicate)		14-Jul-03	9:25 AM	48.87	7%
North Fork @ USFS Rd 9701	YAV 220	14-Jul-03	9:00 AM	42.73	. ,,
West Fork near Mouth	YAV 236	19-May-03	12:15 PM	58.72	2%
West Fork near Mouth (Replicate)	YAV 236	19-May-03	12:30 PM	56.04	- / 0
NF Teanaway @ Dickey Ck (Replicate)	YAV 228	29-Dec-03	9:50 AM	62.79	4%
North Fork @ Dickey Ck	YAV 228	29-Dec-03	9:50 AM	58.45	. 70
Middle Fork near Mouth	YAV 234	10-Feb-03	11:30 AM	64.80	2%
Middle Fork near Mouth (replicate)	YAV 234	10-Feb-03	11:30 AM	62.28	-/-
North Fork @ Dickey Ck	YAV 228	16-Jun-03	9:35 AM	152.15	1%
North Fork @ Dickey Ck (replicate)	YAV 228	16-Jun-03	10:10 AM	152.15	1 /0
North Fork @ Dickey Ck	YAV 228	24-Feb-03	12:00 PM	168.11	8%
North Fork @ Dickey Ck (replicate)	YAV 228	24-Feb-03	11:55 AM	144.45	J /0
North Fork near Mouth	YAV 232	i			3%
North Fork Near Mouth (Replicate)	YAV 232	7-Apr-03	1:00PM	286.68	3 70
rtorum ont real mount (replicate)	171 202	7-Apr-03	12:25PM	305.18	22

Number of Records 22
Average 7%
Number exceeding 20% 2

Blanks Submitted to USBOR Lab for Suspended Sediment & Turbidity Analysis

Site Description	BOR Site Code	Date	BOR Log Number	SS mg/L	Turbidity NTU
Blank	BLANK	4-Dec-02	02-A5541	< 1	< 1
Blank	BLANK	16-Dec-02	02-A5747	< 1	< 1
Blank	BLANK	24-Feb-03	03-A372	< 1	< 1
Blank	BLANK	10-Mar-03	03-A460	< 1	< 1
Blank	BLANK	24-Mar-03	03-A612	< 1	< 1
Blank	BLANK	7-Apr-03	03-A680	< 1	< 1
Blank	BLANK	5-May-03	03-A1081	< 1	< 1
Blank	BLANK	16-Jun-03	03-A1928	< 1	< 1
Blank	BLANK	30-Jun-03	03-A2288	< 1	< 1
Blank	BLANK	14-Jul-03	03-A3003	< 1	< 1
Blank	BLANK	28-Jul-03	03-A3807	< 1	< 1
Blank	BLANK	6-Oct-03	03-A6194	< 1	< 1
Blank	BLANK	20-Oct-03	03-A6398	< 1	< 1
Blank	BLANK	29-Dec-03	03-A7001	< 1	< 1
Blank	BLANK	21-Jan-04	04-A56	< 1	< 1
Blank	BLANK	17-Feb-04	04-A213	< 1	< 1
Blank	BLANK	4-Dec-02	03-A5801	< 1	< 1